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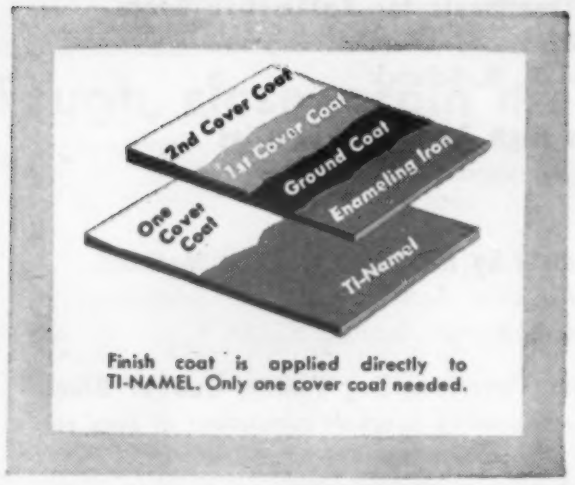

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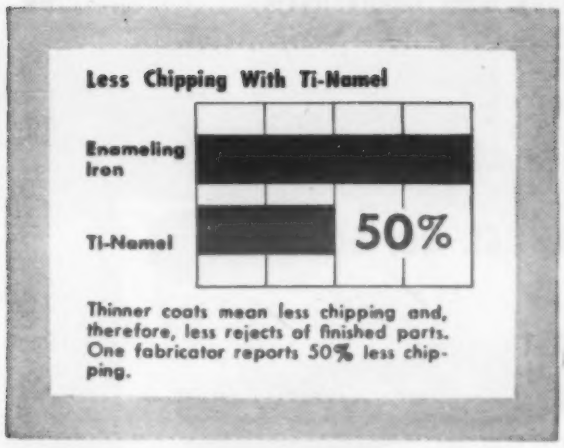

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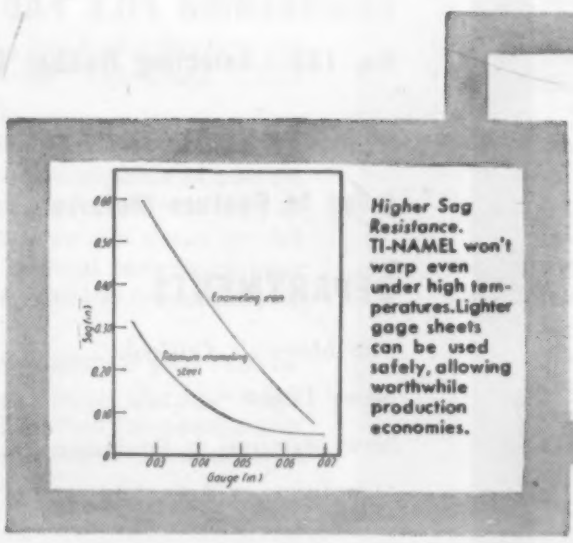

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The Materials Outlook

Business trends continue upward as the first half of the year draws to a close. . . . The expectations of the optimists, as far as first-half business is concerned, have been fully realized . . . and these same expectations are now being pushed through the next two quarters, and in some instances, on into next year. . . . Highlight of the trade reports is the demand for consumers' durable goods. . . . Retail automobile sales have broken all records, despite the complete shutdown of one of the biggest producers. . . . Demand for housing and everything that goes with it has continued strong. . . . Refrigerators, stoves, heating equipment, etc. has been in such short supply in certain areas that some manufacturers have been forced to allocate production. . . . All in all, conditions give every indication of a boom, with no apparent sign of an impending collapse.

Price developments in major nonferrous metals have recently centered about the lead market. . . . A strengthening market coupled with an increased buying movement resulted in a "waiting list" of customers for the first time in many months, despite two minor hikes in prices. . . . Copper and zinc are also in heavy demand despite recent quotation boosts. . . . Tin has sagged slightly.

New chemical materials, two in powder form and one in liquid, have been developed for dip application on steel products that have been pickled and are to be plated or vitreous enameled. . . . The liquid and one powder are mixed with water and used at room temperature in an initial bath. . . . Second powder is used with water in another room-temperature bath. . . . Work remains in each solution for 5 min. . . . Emerges free from dirt, grease, oil, light surface rust and is ready for plating or enameling operations.

One of the satellite materials currently contributing to the popularity of stainless steel, chromium-nickel alloys and Monel is a new high sulfur ester cutting oil that is claimed to improve finish and increase tool life at higher cutting feeds. . . . Support such as this is often responsible for the success of many of the so-called "wonder" metals, the widespread acceptance and use of which would not be possible were it not for the backstage help offered by lesser-known or lesser-publicized materials.

(Continued on page 4)

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The Materials Outlook *(Continued)*

More steel went to the automotive, oil and gas, and farm equipment industries last year than ever before, despite a decline in total steel shipments, according to the AISI. . . . This in itself is indicative of the pace that has been set by the current boom, especially when the effects of large-scale work stoppages such as we have experienced are taken into consideration.

> The application of high tensile wire to form a "live-spiral" flute on the shank of a carbide masonry drill portends great reductions in the time and cost of drilling holes in brick, tile, masonry and concrete. . . . Heretofore, accumulations of dust in the bottom of the hole packed almost solid and effectively reduced the bite of the drill to the stalling point in some cases. . . . With the wire flute, the dust is carried up the drill shank as it accumulates, thus leaving the cutting edges of the drill unobstructed. . . . Another application wherein support is given to better-known materials by lesser-known and much less widely heralded components.

Plastics still continue to be applied to an ever-increasing range of applications . . . and the results justify more than ever before the sagacity of thought that holds that when properly applied, such materials offer an unbeatable combination for utility, low cost, appearance and effectiveness. . . . Latest of such applications include nylon cases for miners' lights, transparent acrylic containers for gold dust deliveries, polythene filter masks, and acrylic display cases.

> With the current building boom, the age-old competition between stainless steel and aluminum for store fronts, building facades, etc. takes on added impetus. . . . Adherents of both materials have long since explored the advantages and disadvantages of their own and their competitors products. . . . Without taking a definite stand, it is felt that both of these materials offer ideal solutions to certain applications and that in the long run availability will play an increasingly important role when the decision is made as to which material will be used. . . . Such are the mixed blessings of a boom. . . . A manufacturer of a product in great demand loses out to a competitor and in doing so, creates a situation that paradoxically enough puts him in a better position for future sales than before. . . . It's no wonder the Russians find our system confusing.

Cold-rolled and galvanized sheet shipments have currently been breaking records in line with most other ferrous production. . . . Particularly in these, however, is the tempo of activity a reflection of the current economic scene. . . . These flat-rolled products are used extensively in consumers' durable goods and in dwelling construction . . . and as these applications prosper, so do the materials from which they are made.

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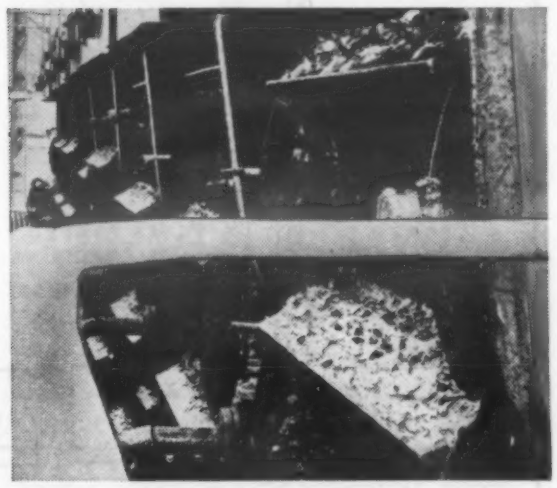
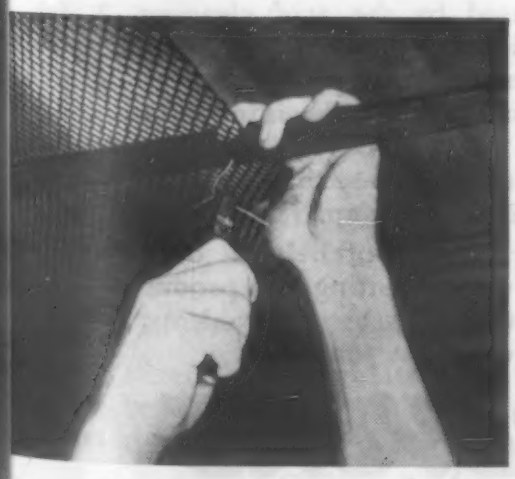
67 Wall Street, New York 5, N. Y.

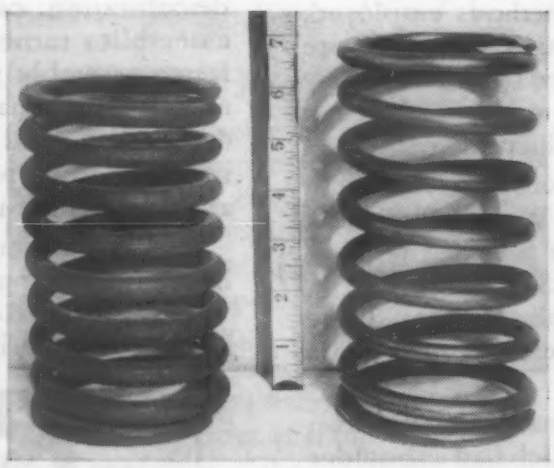
1. *750°F.* is the operating temperature within the Westinghouse Sun Lamp. But Westinghouse has no wire worries. Flexible, 38-strand Nickel wire is used for inside conductors to provide electrical conductivity while resisting heat. The sturdy structural frame supporting the whole assembly is made of "D"® Nickel wire.



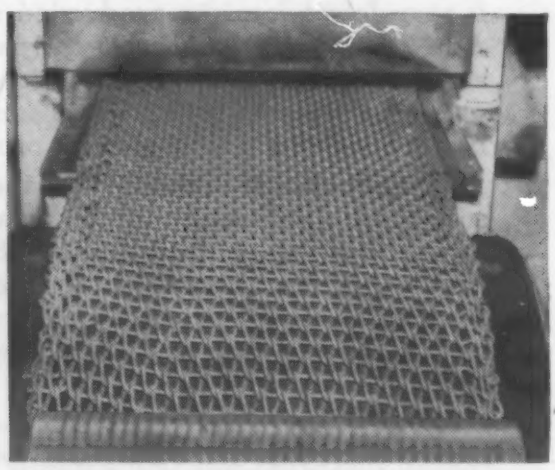
2. *Corrosion* quickly would have ruined ordinary metal wire on these salt-water trash screens. But the operator (a leading chemical company) planned for long life—and got it—with Monel. Installed in 1940, not a single Monel screen has yet to be replaced because of corrosion failure.



3. *Strength* is only one of the many properties needed in architectural tie-wire. Also needed, is resistance to attack by building dampness, lime, cement, plaster. The metal must be workable, too, so that it can be twisted tight without breaking. *Monel* tie-wire ends the wire worries of many architects. "Double-Looping" is not needed.



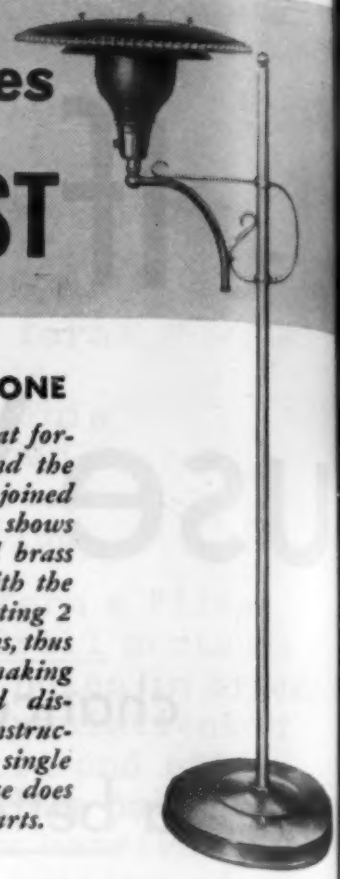
4. *Springs* of Inconel perform well at elevated temperatures. In the above picture, both springs were originally 7" long. After compression testing at 750°F., the spring at left lost 1" of its original height. The Inconel spring (at right) lost nothing. Remember this when you're choosing springs for "hot spots."

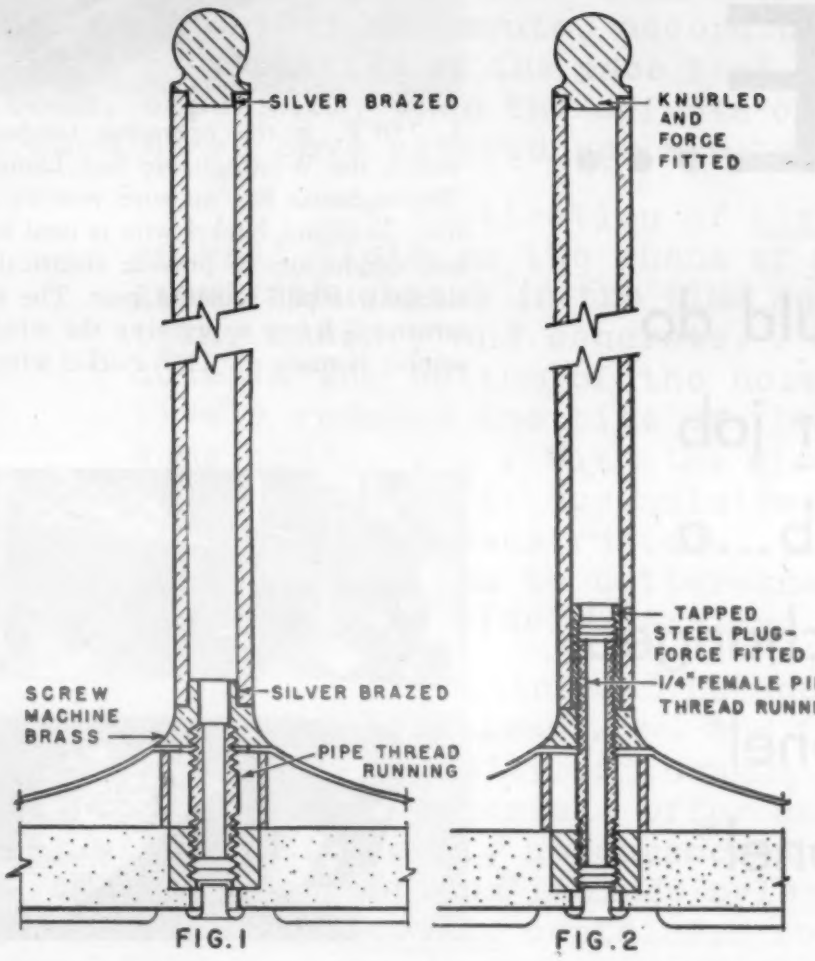


5. *Resistance to oxidation and heat* were twin "musts" for the wire used in this conveyor belt to carry parts through a brazing furnace at 1300-2040°F. Made of woven Inconel wire, this belt was in constant use for more than two and a half years; was still serviceable and strong when the furnace was dismantled.

Sight-Light FLOOR LAMP *Sub-Assemblies*

NOW TURNED OUT 3 TIMES AS FAST





HERE'S HOW IT WAS DONE

Fig. 1 shows the two spots that formerly were silver brazed, and the screw machine brass piece that joined the stem with the base. Fig. 2 shows how top knob and machined brass section that joins the stem with the base are force fitted, eliminating 2 brazing and finishing operations, thus strengthening the lamp and making possible faster assembly and disassembly. Fig. 3 shows base construction simplified even further . . . single screw machine part in the base does the work of three separate parts.

Lamp stem is Revere ¾" O.D. x .680"—.6835" I.D. 70-30 brass tube hard drawn. Support bracket is ⅛" x 1¼" Revere Brass Strip while the outside floor base spun shell is made from 12" wide x .0253 Revere Brass. Screw machine parts at top and base of lamp are Revere 240 type screw machine rod.

Joint efforts of Revere and Plainville Metal Works resulted in elimination of 2 silver brazing and finishing operations . . . faster assembly.

IN working with manufacturers on their various problems, Revere not only takes into consideration how its products can be used to help solve these problems, it also delves into the production methods employed. As a result there have been many cases where Revere and the manufacturer have collaborated to work out new production methods that have not only produced a better product but have also cut production costs.

Newest example of this is the manner in which Revere collaborated with the Plainville Metal Works, Plainville, Conn., in developing the Sight-Light patented reading lamp which they manufacture for the Sight-Light Corp., Deep River, Conn. Originally the knob at the top of the lamp stem was silver-brazed in. Revere suggested this could be a force fit.

Formerly, there had been a screw-machine brass trim section at the base of the lamp stem which had a shoulder on it that was also silver-brazed into the tube. A ¼" running pipe thread nipple with an unthreaded section anchored this screw machine part to the weighted base which was covered by a spun brass disc.

The engineers at the Plainville Metal Works tried various ideas to improve this construction. The final result was a machined section of solid brass that is joined to the lamp stem with a force fit, while the opposite end of this section is threaded for fastening to the base.

Results: 1. Elimination of two silver brazes. **2.** Elimination of two finishing operations, one of which was acid cleaning, and the other, the removal by hand of the discoloration caused by the acid cleaning. **3.** Subassemblies turned out 3 times as fast through a new, faster assembly method that permits finishing before assembly on a mass production basis instead of by hand. **4.** A substantially stronger lamp. **5.** A trim, one-piece screw-machine part at the base that is turned out faster and in a single machine set-up.

Perhaps Revere can be of help in developing or improving your product—cutting your production costs. Why not tell Revere *your* metal problems? Call the Revere Sales Office nearest you today.

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News Digest

Synchrotron Features New Design

A non-ferromagnetic synchrotron ultimately expected to produce X-rays of 300 million volts is being built under the joint sponsorship of the General Electric Research Laboratory and the Office of Naval Research. It will be used to study the effects of high-energy radiation, particularly in nuclear research.

The new machine is of a design which eliminates the large iron-core electromagnet commonly used in such devices; the powerful magnetic fields

GE scientists tinker with a new type of atom smasher.

required are produced solely by specially designed coils of wire.

The synchrotron has been operated thus far up to about a million volts, but is expected to be operating at much higher energies before the end of the year.

Jet Use Silver-Plated Bearings

A thin silver plate, about 0.001 in. thick, is being used on the bronze retainers of roller bearings to prevent seizing in jet aircraft engines, according to an announcement by SKF Industries, Inc. The silver-plated retainers are in bearings which support the jet's main turbine shaft and are, therefore, subjected to extremes in operating speeds and temperatures.

New Materials Described at Powder Metallurgy Sessions

The powder metallurgy industry is growing. This fact was demonstrated by the quantity and quality of attendance at the Sixth Annual Meeting and Exhibit of the Metal Powder Association held in Detroit, April 25-26. Nearly five hundred technical men registered for the two-day meeting and another couple of hundred visited 24 exhibits that displayed the latest advances and developments in the industry.

The technical program opened with an informal discussion led by Fred P. Peters, MATERIALS & METHODS, and T. L. Robinson, Wel-Met Co. Many of the current problems confronting the industry were discussed at this session. Some of these included the cost of metal powders, the need for standardization within the industry, the ever-present problem of plating and brazing metal powder parts, and the feasibility of producing high density structural parts.

The formal papers covered a wide range of subjects, and following is a brief review of them.

Stainless Steel Powders

Several obstacles beset the metal powder parts producer in attempting to use stainless steel powders. These are poor moldability, high sintering temperature, and the need for high purity, low dewpoint atmospheres. A paper by George Stern, American Electro Metal Corp., titled "A New Type of Stainless Steel Powder," describes two grades of stainless powder that overcome some of these common objections. While it is not claimed that these powders can be sintered at lower temperatures, nor that they do not require high-purity, low dewpoint atmospheres, these powders do have good green strength and moldability. In addition, by sintering in gettered boats, some of the objections to low dewpoint, high purity atmospheres can be overcome.

While the method of producing the powders is applicable to many types of alloys, only two stainless steel powders were considered in this paper. One was essentially 14% chromium, balance iron; the other was a 17 to 18 chromium, 8 to 9% nickel composition. Tests of these powders showed that their green strength is three to ten times higher than commercial alloy powders of similar chemical composition. When pressed and sintered at 2372 F, both grades developed mechanical properties which indicate their suitability for many part applications. Their corrosion resistance is comparable to the wrought alloys.

The possibility of infiltrating these powders with silver and copper was investigated. Resulting high mechanical properties indicate that infiltrated stainless powder parts might be suitable for special applications. (An article on these stainless steel powders will appear in the July issue of MATERIALS & METHODS—*The Editors*).

Coated Metal Powders

The idea of coating hard brittle powders like cast iron with a softer metal, such as copper, tin or nickel, or any combination of these, has always been attractive, because such a coating can change the hard brittle powder into one that has good green strength and can be readily molded. A number of different methods to produce coated metal powders have been investigated in the past, but none have found wide commercial application. Recently a new process employing an exothermic reaction

News Digest

similar to that of the well-known Thermite process has been developed. The metal powders thus produced were described in the paper "Thermochemical Coated Metal Powders," by J. E. Drapeau, Jr., Metals Refining Co.

Cast iron powder coated with copper by this method is stable and can be readily milled, screened and blended into a metal powder that looks like copper. A cast iron powder coated with 20% copper, for example, is easily compacted into solid shapes very similar to straight copper powder.

Cast iron powders have also been coated successively with a mixture of copper and lead oxide to produce a coating consisting of firmly adhering particles of copper and lead. Also, cast iron powders have been produced by this method with coatings of nickel, and mixtures of copper and nickel.

The results of preliminary tests on the above powders have indicated that ferrous powders which are normally not briquettable because of hardness can be made suitable for pressing at normal pressures by applying soft metal coatings. In addition, the tests showed that relatively strong sintered parts can be obtained with these coated metal powders sintered in reducing atmospheres between 1800 and 2200 F.

Friction Materials

An important application of metal powders is as an ingredient in friction materials. In his paper "The Use of Metal Powder Parts as Friction Materials," L. Kane, of S. K. Wellman Co., described in detail this application.

Metal powder friction material is composed of a sintered mixture of metal and non-metal powders. The most commonly used powders are copper, iron, tin, lead, graphite and silica. Primarily, metal powder friction material is justified on its performance rather than its first cost, because its cost is generally higher than that of competing friction materials.

Some of the economic and functional advantages of metal powder friction materials are as follows. Due to the ability of metal powder friction material to absorb energy at higher rates than most organic or mineral friction materials, it can be used at higher temperatures and at greater pressures and speeds. This means smaller, lighter and more compact designs. It also means more wear resistance and better life for both the metal powder friction surface and the opposing surface. And it means less distortion, heat checking and scoring of the opposing surface.

Another advantage is that these materials are not affected appreciably by climatic conditions, such as heat, cold, dampness, salt water and fungi. Within a practical range they are inert to chemical changes caused by heat, water, oil, solvents, fungi and salt water.

Metal Powders in Cores

Another important use of metal powders is in a wide variety of cores used in electrical and electronic equipment. F. E. Edwards, Standard Coil Products Co., Inc., ably reviewed this application in his paper "Application of Iron Powder in Radio and Television Circuits."

The primary advantage of using metal powders for cores is that with them loss is low at high frequencies. In manufacturing cores, the metal powder particles are first insulated with a non-conductive coating and then molded by regular powder metallurgy techniques. Cores can also be manufactured by extrusion methods.

A number of different powders are used in core manufacture. These include (1) hydrogen-reduced iron powder which is still being used for low frequencies; (2) magnetite and synthetic oxides; (3) carbonyl powders which have better loss factors and are the most stable powder; (4) the relatively new ferrites which have extremely high permeability and high inductance; and (5) flake powder materials which are low in cost, and have appreciably higher permeability than all others except the ferrites.

Two papers of a non-technical nature were also presented. Of particular interest to the metal powder producer and the parts fabricator was the paper. "Metal Powders in a Competitive Market," by John Sasso, of *Business Week*. He pointed out that powder metallurgy was still young and in much the same position as was the plastics field in its younger days. Several suggestions were offered to increase the rate of growth of the industry, and among these were (1) less secrecy within the industry, and (2) better promotional activities to educate engineers and designers on the capabilities of powder metallurgy. To support this second suggestion, the author quoted excerpts from interviews with persons in leading industries throughout the country, who were asked their opinions of powder metallurgy as an engineering production method.

A. J. Langhammer, Amplex Manufacturing Co., presented a paper on "Cost Accounting with Reference to Powder Metallurgy Products." The author outlined in detail methods of setting up efficient and accurate cost accounting systems, and listed the many cost factors which must be considered in arriving at the cost of producing various metal powder parts.

New Optical Glass Developed

An easily-molded glass which can also transmit infrared rays of extremely long wave lengths has been developed by Rudolph Frerichs of Northwestern University. These two characteristics are expected to make the new glass useful for certain research instruments and industrial processes, and for military weapons actuated by infrared rays.

The new glass has a melting point below 570 F. It also has a high index of refraction. By a change in composition, the glass can be made entirely opaque to block out all visible rays, if desired, while still transmitting infrared rays. Arsenic and sulfur are the two elements used in the reddish-colored glass.

One use anticipated for the glass is in lenses for infrared spectrographs used in industry. Up to now, different kinds of natural or artificial crystals, such as quartz or rock salt, have been used. The size of these optical parts has been limited because the lenses and prisms have to be cut and ground from available stock. The good formability of the new glass is expected to remove this size limitation.

Varied Technical Sessions, Exhibits Planned by ASTM

Symposiums on gas turbine materials, nondestructive testing, high temperature metal properties, and sessions on nonferrous metals and nonmetallic materials will feature the 1950 Annual Meeting of the American Society for Testing Materials at Atlantic City, June 26 to 30. Also running concurrently with the meeting will be an exhibit of testing apparatus and related equipment in which leading manufacturers of materials testing equipment will participate. The popular photographic exhibit on "Materials, Testing and Research" will be held again this year in conjunction with the apparatus exhibit.

Other highlights of the meeting will be the committee meetings, which will number approximately 400, and the Marburg Lecture, to be delivered this year by W. R. Brode, National Bureau of Standards, on the subject of Chemical Spectroscopy.

Technical Program

Twenty-three formal technical sessions and a number of round-table discussions and informal meetings are on the program. A brief resumé of those sessions which should be of particular interest to our readers is given below.

High Temperature Materials—A diversified program is being developed on the properties and use of materials at high temperatures. A symposium on the Corrosion and Erosion of Gas Turbine Materials on Monday afternoon will provide latest information from important investigations on corrosion of various kinds of metals used in gas turbines. Coal ash and oil ash corrosion are the subjects of two papers, and other papers will discuss creep, stress-rupture, and stress corrosion properties of various turbo-supercharger materials.

A round-table discussion on heavy forgings Tuesday morning will be of interest to all manufacturers, users and designers of gas turbines. Some of the many perplexing problems involved in the use of forgings, particularly in the gas turbine field, will be discussed.

A symposium on Effect of Sigma Phase on High Temperature Properties of Metals will be conducted in two sessions, Monday evening and Tuesday afternoon. Some of the topics to be covered include: structure and impact resistance of columbium-bearing 18:8 steels; effect of sigma phase on the mechanical properties of columbium-stabilized weldments in austenitic stainless steels; and effect of sigma phase on several cast austenitic steels and cast iron-nickel-chromium alloys.

Nondestructive Testing—A symposium to acquaint engineers and management with the advantages and uses of nondestructive testing will be held in two sessions on Tuesday. Six papers will survey the wide ranges of applications of all the nondestructive testing and inspection methods, and will show how their proper use can reduce production costs and improve product quality.

Nonferrous Metals—The first of two sessions dealing with nonferrous metals is on Thursday morning and includes papers on use of magnesium-cerium wrought and cast alloys and aluminum-6% magnesium alloys for elevated temperature service. Friday afternoon the session will have papers on corrosion and on the forming characteristics of beryllium copper strip.

Fatigue Properties—On Wednesday afternoon four technical papers will be given, dealing with fatigue and endurance properties of materials. The subjects to be covered are: effects of grinding and other finishing processes on fatigue strength of hardened steel; effect of chromium plating on endurance limit of aircraft steels; combined tension-torsion creep-time relations for aluminum alloy 2S-O; and effects of anodic coatings on fatigue strength of aluminum alloys.

Effect of Temperature—Two technical sessions on Wednesday and Thursday morning will include a series of papers covering the properties of ferrous and nonferrous metals at elevated temperatures. Subjects of the papers include hardened alloy steel for service up to 700 F; mechanical properties of austenitic stainless steels; hardening of steels by mechanical working at sub-zero temperature; and chromium-base alloys.

American Electroplaters Seek Lower Finishing Costs

Reduction of finishing costs will be the theme of the annual convention of the American Electroplaters' Society, to be held June 12 to 15 in Boston, Mass. This meeting will be combined with the Fourth International Conference on Electrodeposition, and will be held in collaboration with the Electrodepositors' Technical Society of Great Britain.

Five educational sessions are scheduled, in addition to a number of committee meetings and informal outings for convention participants and guests. A brief outline of the subjects to be discussed during the technical sessions is given below.

Two sessions will be devoted to the problems encountered in the smoothing and leveling of electrodeposits. The measurement of surface smoothness will be covered in two papers. Other subjects include smoothing by chemical and electrochemical polishing, leveling with PR current plating, micro-throwing power of plating solutions, leveling in cobalt-nickel plating solutions, and surface contour and leveling.

Abrasive tumbling and abrasive belt polishing of metals will be covered in two papers to be presented at the mechanical finishing session. In addition, a water-base buffing liquid will be described and reductions in polishing cost obtained by using flat-polished phosphate-coated steel will be explained.

The opening general session will include two papers dealing with electrodeposition in connection with the graphic arts. One will review recent developments; the other will discuss high-speed nickel plating of curved stereotypes. A report from abroad will also be presented; it will cover electroplating and metal finishing developments in Germany during the

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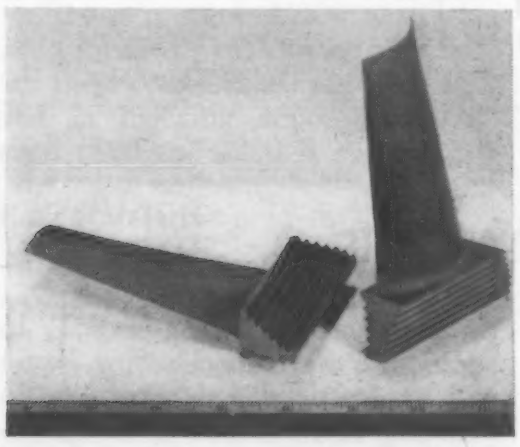
past decade. Other subjects listed for this session include a self-regulating high-speed chromium plating bath and the nodule method of measuring adhesion of electroplated coatings.

The final session will be devoted to research reports. It will include a paper on the reporting and use of research data, as well as reports on porosity research and on the use of radioactive isotopes for determination of current distribution.

Metal-Refractory Turbine Blades Must Overcome Several Problems

One of the most important applications anticipated for metal-refractory materials now under development is gas turbine blading. (These metalloid combination materials were discussed in some detail in MATERIALS & METHODS, May 1950, p. 59). Despite optimism in certain quarters, there are a number of reasons why successful and economical use of metal-refractory turbine blades may be some time off.

One problem which is not likely to be eliminated is that of brittleness; it is generally accepted that metalloid blades must be handled with considerably more care than metal blades.



Small cemented carbide blades are now being produced. (Courtesy Kennametal, Inc.)

Thermal Conductivity

Thermal conductivity of these materials is generally higher than that of alloys presently used for turbine blades. Here it is perhaps better to consider rotor and stator blades separately. High conductivity is advantageous in stator blades, for "hot spots" are not so likely to develop, but in rotor blades, high conductivity causes the rim of the disk to run hot, thus posing another materials problem. These two classes of blading also differ in strength requirements. Although stator blades are not subjected to the centrifugal forces that act on rotor blades, they are believed to bear the brunt of the thermal shock which occurs when the fuel supply is cut off. It is evident, then, that blading problems are not uniform. First blades used in production engines are expected to be stator blades, and will probably be small.

Dimensional control is also an important consideration. Experimental blades of Kentanium, Kennametal's cemented carbide material, are being fabricated by cold pressing the powder mixture into rectangular compacts, machining them to blade shape, then sintering. Past experience, both in this country and abroad, has shown that shrinkage during sintering makes dimensional control poor. However, blade lots recently produced by Kennametal are reported to meet tolerances of 0.002 in. and lower, so it appears that improved fabrication techniques are being developed.

Fabrication and Cost

In addition, entirely different methods of fabrication, including extrusion and hot pressing, are being investigated. Most of this work is still under wraps, but hot pressing of cemented carbides, at least, is believed to offer little advantage for turbine blades.

The most important problem is cost. This factor is sometimes minimized by producers operating under government contracts, but imminent cutbacks in government spending force a realistic economic appraisal.

The consensus on turbine blade fabrication is that, except for shapes which can be rolled, machining, however complex, is cheaper than any other production method, including casting and forging. Kentanium blades are now being machined on multiple-spindle contour forming machines, and it is reported that some blade shapes may soon compare favorably in cost with metal blades. Of the metal-refractory materials developed so far, this cemented carbide appears to be potentially the most likely for gas turbine blades. Right now, however, there can be little doubt that cost of these blades is too high for either commercial or extensive military application.

Electron Microscope Simplified

An electron microscope, reduced in size, complexity and cost, but offering magnifications up to 50,000 diameters by photographic enlargement, was announced recently by Radio Corp. of America.

The new instrument has a 50,000-volt accelerating potential and provides direct magnification up to 6000 diameters. It is more than 20 times as powerful as the best optical microscope, with a depth of focus 150 times as great.

The simplified construction has been obtained primarily by use of permanent magnet lenses requiring no stabilization circuits. The lower size and cost of the new instrument are expected to greatly extend the application of the electron microscope in metallurgical investigations, as well as in many other fields.

Production, Use of Electric Power Displayed in G.E. Exhibit Train

A 10-car exhibit train, called the More Power to America Special, was unveiled in New York recently by General Electric Co. It is an attempt to display, in one series of related exhibits, a complete range of products for the production, distribution and utilization of electric power.

The streamliner is scheduled to visit about 150 key industrial centers during 1950 and 1951. At each stop, the train will be inspected by invited representatives of electric utilities, manufacturing and transportation industries, the armed services, the Federal Government and municipalities. It will not be open to the general public.

The train contains exhibits of more than 2000 of the most modern electric products, systems and techniques grouped in 11 sections: power generation, transmission and distribution; drives and controls, materials handling, welding, industrial heating, renewal parts, industrial lighting, components for industry, measurements, civic improvement and national security.

Machining, Forming Developments Reviewed at ASTE Meeting

The most recent advances in the machining and forming of metals came in for discussion at the annual meeting of the American Society of Tool Engineers held in April at Philadelphia. Some of the information presented in several convention papers has been summarized below.

Nitriding High-Speed Steel

Immersing heat treated high-speed steel tools in molten cyanides for varying periods of time at temperatures of from 950 to 1100 F is now standard practice. This nitriding process results in an increase in surface hardness from a Knoop microhardness number of about 850 for an unnitrided tool to about 1050 to 1150 for a nitrided tool. High-speed tools so treated tend to maintain much keener cutting edges.

In "Some Notes on the Nitriding of High-Speed Steel," J. G. Morrison, of Landis Machine Co., described a series of experiments carried out to determine if any substantial improvement in the impact or bend test properties could be made. In general he found that the stress-relieving of nitrided specimens did not produce any significant improvement in these properties. The stress-relief treatments used were 1 hr. at 700 F and 1 and 2 hr. at 1000 F.

However, stress-relieving did lessen the magnitude of radial cracks around Rockwell hardness test impressions; and there was less tendency toward minute spalling of the edges in the polish preparation. The 1000 F treatment also lessened the tendency toward minute spalling of the cutting edges in regrinding.

The 18-4-1, Type M2, Type M1 and the molybdenum-vanadium steels appear to respond equally well to the nitriding treatment. That these nitrides are quite stable is indicated by the small difference in microhardness numbers observed between stress-relieved and as-nitrided specimens.

Hard Chromium Plating

The range of applications of hard chromium plating was described by Brayton A. Taylor, Chrome Electro-Forming Co., in a paper entitled "Hard Chrome Plating." The typical hard chromium plate is relatively thick, 0.0005 to 0.01 in., and is applied directly to the base metal. It is generally applied to new tools and gages for securing increased production life; to used tools to bring them back to original specified dimensions or to new requirements; and to many types of machined or formed parts and products to provide abrasion-resistant surfaces.

Specific applications include ball bearings, outboard cylinders, cylinder bores, gun barrels, powdered metal dies, taps, extruding dies, drill jig bushings, thread gages, broaches, drills, burnishers and piston rings.

Another application is in plastics molds where heavy wear, harsh abrasive materials, chemical corrosion, high pressures and temperatures, and close tolerances are encountered. Hard chromium plating from 0.0003 to 0.0005 in. thick provides a smooth, dense surface which results in better flow of compound, higher finish on molded pieces, easier extraction from the mold, and better uniformity of molded pieces.

Investment Casting Design

Full utilization of the capabilities of the investment casting process will be realized only when parts are designed as castings. Some of the factors which must be considered in this connection were outlined by T. F.

(Continued on page 120)

IT'S A FACT
FOUR-A JOSEPH'S
IF ASKED TO NAME ALL THE KNOWN METALS IN THE WORLD FEW OF US COULD GIVE MORE THAN TWENTY. YET THE TOTAL LIST IS SOME SEVENTY KINDS OF METALS
OF THESE ABOUT THIRTY ARE USEFUL TODAY
THE HOLLOW-GROUND STEEL HEAD OF AN ELECTRIC RAZOR REQUIRES OVER 100 PRECISION OPERATIONS TO MANUFACTURE
AN IRON BLADE
PROBABLY 5,000 YEARS OLD, HAS BEEN FOUND IN ONE OF THE EGYPTIAN PYRAMIDS CONFIRMING THE BELIEF THAT THE EGYPTIANS MUST HAVE REQUIRED TOOLS OF IRON TO BUILD THE PYRAMIDS ABOUT 4,000 B.C.

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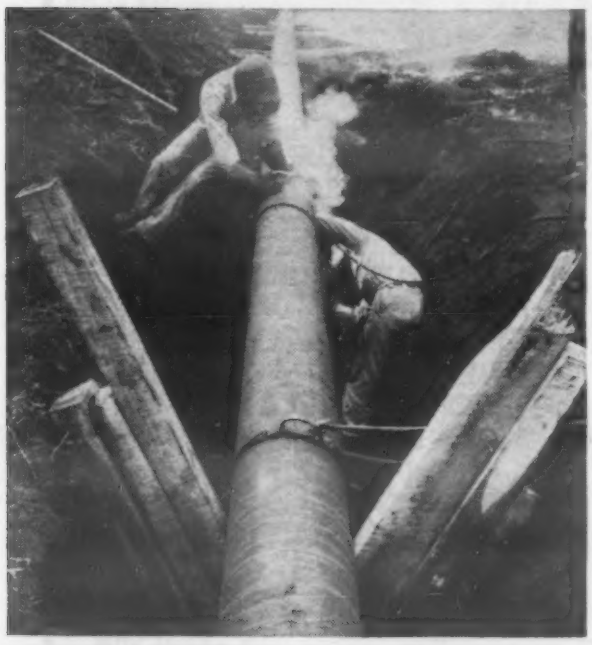

TYPE W-22—AWS E6010, d-c reverse polarity, all positions; recommended for all types of joints in mild steel. Produces welds of excellent appearance, high tensile strength, ductility, and high impact resistance. Typical applications include pipe-lines, shipbuilding, structural frames, tanks and pressure vessels.

TYPE W-27—AWS E6020-30, a-c/d-c, flat and horizontal positions; recommended for high-speed production of butt and fillet welds on mild steel. Permits higher speeds than other production electrodes, making it particularly suited to jobs where distortion must be minimized.

TYPE W-28—AWS E6012, a-c/d-c straight polarity, all positions. Designed for mild steel, general-purpose welding, this electrode possesses a very stable arc without excessive arc force. Excellent fusion, good appearance with minimum convexity, and easy slag removal.

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712-1

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JUNE 1950

What Tensile Properties of Metals Mean in Design

Although the tensile properties are well-known to engineers and designers, their true significance and limitations are often overlooked. Here is a simple and clear explanation of their practical meaning and how they should be used in metals selection and design.

by JOHN B. CAMPBELL, Associate Editor, Materials & Methods

• OF ALL THE mechanical properties commonly determined for metals, the tensile properties are probably the most familiar to engineers and designers. Thus, *modulus of elasticity* indicates flexibility; *yield strength,* the maximum load-carrying capacity without permanent deformation; *tensile strength,* the maximum load-carrying capacity without failure; and *elongation* and *reduction of area,* the ductility of the metal. Yet many design failures can be traced directly to the misinterpretation or misuse of these same properties. The consequences of such failures are usually severe: loss of time, money—and, sometimes, lives.

The proper use of tensile properties requires careful consideration of a large number of factors. Few of them are complex, but many are often overlooked. In this article, therefore, an attempt will be made to explain simply and clearly the practical meaning of the tensile properties, and to show to what extent they can be used in metals selection and design.

Much confusion and many design failures could be avoided by keeping in mind that the so-called mechanical "properties" are actually not inherent properties of the material, but are merely the results of arbitrary load tests performed according to more or less standard procedures.

In the tensile test, a standard specimen is gradually stretched in its longitudinal direction until it fractures. Specimen design varies according to the specific material and form being tested, but the most common one is a ½-in. machined cylindrical bar with larger threaded sections for gripping at each end. During the test two essential measurements are made: stress (or load) and strain. These terms are defined as follows:

Stress—the intensity of the internal distributed forces which resist a change in the form of the body; or, load per unit area. Units: pounds per square inch.

Strain—the change per unit length in a linear dimension of a body, which change accompanies a stress. Units: inches per inch, or percent.

The simple nature of tensile loading and the important concepts of stress and strain should be kept in mind throughout the following discussion.

The purpose of any set of mechanical properties is to enable the engineer to (1) predict the behavior of the metal during fabrication, (2) predict the behavior of structures fabricated from this material under actual service conditions, and (3) compare the material with others for both fabrication and service.

In pursuing these aims, the engineer should ask himself several questions about each property in order to establish its usefulness and reliability. These questions will be presented briefly here and discussed in more detail for each of the tensile properties under consideration.

1. *How was the property determined and what is its practical definition?*

2. *How sensitive is the property to changes in test conditions?*

3. *How sensitive is the property to changes in composition of the alloy?*

4. *How sensitive is the property to changes in mechanical or thermal treatment of the alloy?*

5. *To what extent can this property be used to estimate other mechanical properties that may be useful?*

6. *What is the relation between this property and practical fabrication or service conditions?*

Since conditions encountered in any two applications are never exactly the same, the answer to this last question must be separate for each different application. All that can be done in a discussion of this nature is to indicate those factors which should be taken into careful consideration. In the last analysis, then, the proper use of the tensile properties of metals is a matter of judgment.

Modulus of Elasticity

The ability of a rubber band to return to its original size and shape after being stretched is a familiar phenomenon. This property of rubber is called elasticity. It is sometimes hard to realize that an apparently rigid material like steel has the same property. The reason, of course, is that a much greater stress must be applied to steel to produce the same amount of stretching; furthermore, steel cannot be strained to the same extent as rubber without being permanently deformed. Materials differ from one another in elasticity, and that is why the property called modulus of elasticity is often of interest to the engineer. In the tensile test, this property is determined by dividing the stress in the specimen at any instant by the overall strain corresponding to that stress, provided that the stress is low enough so that if the load were released the specimen would return to its original dimensions. Modulus of elasticity is ordinarily expressed as pounds per square inch.

Modulus of elasticity is independent of testing conditions. For this reason, it is often classified as a physical property rather than a mechanical property. Since it is generally determined from the tensile test, however, it will be treated here as one of the tensile properties.

Each major group of structural alloys has a characteristic modulus of elasticity. Thus, steels run about 30 x 10^6, cast iron about 15 x 10^6, copper alloys about 16 x 10^6, and aluminum alloys about 10 x 10^6 psi. (For some materials, notably cast iron, which do not demonstrate true elasticity the reported moduli are only approximations.) Except where large amounts of alloying elements are involved, as in some brasses and bronzes, the differences in modulus of elasticity among alloys of the same base metal are slight. For any given alloy, the differences in modulus of elasticity caused by composition variations within the specification limits are so slight as to be absolutely negligible.

The modulus of elasticity of a material cannot be changed by mechanical or thermal treatment. Therefore, modulus values are not affected by variations in such fabrication processes.

The modulus as determined in the tensile test is about the same as that determined by a compression test. The modulus as determined in the shear test generally runs about 40% of the modulus of elasticity in tension. So modulus of elasticity (used alone, this term always refers to the tensile property) can be used to estimate the compressive modulus or the shear modulus (modulus of rigidity) if desired. It cannot be used to estimate any other common mechanical properties.

Since modulus of elasticity is the ratio of stress to strain, but is expressed as a stress, it is obvious that a modulus value is actually the theoretical stress required to produce a strain of one inch for every inch of length. In other words, if a steel rod could be stretched to twice its original length without being permanently deformed, a stress of 30 x 10^6 psi. would be required to do it. For metals, this is an absurd consideration. Viewed alone, then, a figure representing modulus of elasticity has no practical significance. The modulus of elasticity does become of practical importance when it is used in conjunction with a known stress or a known strain.

For a simple example, suppose that a ½-in. mild steel rod 100 in. long is stretched under a load of three tons. This is equivalent to a stress of about 30,000 psi. The strain in the rod would then be equal to the stress (30,000 psi.) divided by the modulus of elasticity for mild steel (30 x 10^6 psi.) or 0.001 in. per in. Since the rod is 100 in. long, the total stretch would be 0.1 in. This does not seem like a large stretch for a member 100 in. long, yet it is not hard to imagine certain applications where strains that large and even considerably smaller would be of great importance. If the material in this example had been aluminum, with a modulus of 10 x 10^6 psi., the total stretch would have been three times as great, or 0.3 in.

Similarly, the modulus can be used to calculate deflections in bending, though geometric considerations make the mathematics more complex. Here it will be sufficient to point out that if two horizontal beams of identical cross-section, one of steel and the other of aluminum, are loaded equally (the weight of the beam must be considered part of the load) and at corresponding points, the aluminum beam will sag exactly three times as far as the steel beam. If these same loads are applied and released alternately, the beams will alternately sag and spring back; and the aluminum beam will be three times springier than the steel beam.

It is evident that where applied loads are not great enough to produce permanent deformation, modulus of elasticity measures stiffness or the resistance of the material to stretching. The higher the modulus, the stiffer the material; the lower the modulus, the more flexible the material.

In many applications, the greater stiffness represented by a high modulus of elasticity can be more important than strength. In shafting and pump rods, for instance, alloys having high moduli of elasticity show less whipping and vibration and, consequently less tendency to wear unevenly in bearings. For example, a 1-in. shaft strong enough for a given application might be unsuitable because of excessive bending. One solution to this problem would be to use a heavier shaft or provide extra bearings. But a material with a higher modulus of elasticity might overcome this difficulty and make it unnecessary to increase either shaft size or number of bearings.

Yield Strength

There is a limit to the amount of stretching a steel bar can take without showing some dimensional change when the load has been released. Unfortunately, it is hard to determine exactly the lowest stress needed to produce permanent deformation. It is, therefore, customary to approximate this stress by means of a property called yield strength. There are two widely used methods of measuring yield strength. For steels and light metal alloys it is usually measured at 0.2% offset or 0.2% set; here the yield strength is roughly the stress required to produce a permanent deformation of 0.2% or 0.002 in. per in. strain. For some nonferrous metals, notably the copper alloys, yield strength is measured at 0.5% extension under load; this means that it is the stress required to produce a total strain of 0.005 in. per in. before load is released. Metals strained to this extent do not return to original dimensions. Thus, it appears that yield strength, as an approximation, is somewhat higher than the lowest stress required to produce permanent deformation.

Yield strength is rather sensitive to variations in test conditions, particularly specimen alignment, speed of testing and temperature. But years of development have produced equipment and techniques which make the results of carefully run tests highly reproducible. In comparing the yield strengths of two materials, it is important to note whether the same basis has been used in reporting the two values. The yield strength of an alloy steel, 90,000 psi. at 0.1% offset, might be 95,000 at 0.2% offset. And a greater stress is generally required to produce 0.5% extension under load than 0.2% offset. Thus, a reported yield strength (0.2% offset) of 60,000 psi. for an aluminum alloy cannot be compared directly with a reported yield strength (0.5% extension under load) of 65,000 psi. for a bronze. The two materials may be equally strong.

Yield strength is greatly affected by variations in alloy composition. That is why the yield strength of a given alloy is often presented as a range of values. Generally, this range should be narrow for simple alloys and wide for more complex alloys to allow for the possibility that all of the alloying elements are close to the lower or upper composition limit, as the case may be. Within the composition limits of any given alloy, it is generally true that yield strength increases as alloy content increases. This is particularly so in the case of carbon in steel; the difference between the low and high limits on a plain carbon steel, namely 0.05%, can make a difference of as much as 5000 psi. in yield strength.

Considerable changes in yield strength are caused by variations in heat treatment or in the amount of mechanical working of a metal. Invariably, the greater the amount of mechanical working for the same steel, the higher is the yield strength. In the case of steel, the higher the tempering temperature for the same alloy, the lower the yield strength. In nonferrous alloys, where time of aging is often an important variable, the case is not so simple. Up to a certain point, the longer the aging of a particular alloy, the higher the yield strength; beyond that point, the yield strength begins to decrease as aging continues. It is evident that these changes can be more easily estimated in ferrous than in nonferrous alloys. In general, however, considerable care must be used in estimating the yield strength of an alloy subjected to entirely different mechanical or thermal treatment.

When considered separately for the different groups of alloys, yield strength can be used to estimate tensile strength, hardness and the endurance limit. These relationships, however, can be more accurately based upon hardness values.

Most structural parts can be made useless without being broken. Even small permanent deformations can render a part unsuitable for further service. That is why yield strength, roughly the maximum stress to which a metal can be subjected without assuming permanent deformation, is one of the most important mechanical properties for design purposes.

It is important to remember, however, that yield strength is determined by the reaction of the metal to a single and gradual application of load parallel to the direction of the greatest dimension of the part. The result of such a test is not directly applicable where there are heavy stresses in more than one direction or where a load is applied suddenly or repeatedly.

For metals expected to withstand sudden or repeated loading, special mechanical tests (impact strength, endurance limit) have been developed. Yield strength is generally not a satisfactory index of the resistance of a metal to such loading. Other factors being equal, however, it can be said that the higher the yield strength, the higher will be the stress at which the metal can support infinite repetitions of load (endurance limit).

Even for structures to be subjected to a single, gradually-applied load, it would be impractical to design directly on the basis of yield strength. One obvious reason is that yield strength, by definition, implies a certain amount of permanent deformation. And it is only reasonable to expect that the condition of the material may vary somewhat from that of the test material; and that service stresses may occasionally be higher than those predicted. In order to make allowances for these variations, it is necessary to select a "significant" strength somewhat lower than yield strength but high enough so that the design will be economical.

It is customary to choose a significant strength by applying a rather arbitrary safety factor to yield strength or ultimate strength, with yield strength much to be preferred. Thus, the commonly used safety factor of 2.0 based on yield strength means that the design or significant strength is calculated by dividing yield strength by 2.0. The safety factor is intended to account for all the variables known to affect the stress in a member and the strength of the material, such as type of loading, unexpected load peaks, stress concentration, corrosion effects, etc.

The safety factor is convenient and will continue to be used where its value is based on considerable experience with parts similar to those being designed. The danger arises when an old safety factor is projected to a new set of conditions arising from changes in the processing of the material or the functioning of the part. These considerations are particularly important where repeated loading is involved. For such applications, the trend today is toward use of a "design factor," which is intended to account only for those factors that

are beyond the control of the designer. This method, which requires that all factors affecting stress and strength in a member be considered individually, is applicable especially to structures with which the designer has had little or no experience.

Whether a given design or safety factor is adequate must be determined separately for each structure. The decision must be based on judgment and experience, with economic production, the consequences of failure and the desired degree of performance taken into account. When the unknown factors affecting significant stress and strength can be reduced to a minimum, a design factor as low as 1.3 is adequate insurance against failure. At the other extreme, if the effect of these factors cannot be established, a design factor of 2.0 is required.

In addition to its use in design for service, yield strength serves to indicate to some extent the ease with which a metal can be formed during fabrication. Since forming involves permanent deformations, it is clear that a low yield strength is desirable for fabrication purposes. The forming process itself tends to raise yield strength so, as forming continues, it is often necessary to anneal the alloy in order to lower yield strength once more. In summary, then, a high yield strength is desirable for service, undesirable for fabrication.

Tensile Strength

As a steel bar is stretched in the range where permanent deformation occurs, the load continues to increase but at an ever-decreasing rate. Eventually a maximum load is reached; then the metal "necks down", *i.e.*, stretches while the load remains the same or decreases. Finally, the metal fractures. (Sometimes fracture occurs at maximum load.) The maximum load supported by the metal, when divided by the original cross-section area, becomes a stress and is known as tensile or ultimate strength.

In its sensitivity to variations in test conditions, alloy composition and thermal or mechanical treatment, tensile strength is much like yield strength. The effects of such variations are in the same directions and of much the same magnitudes. Similarly, since approximate relationships between yield strength and tensile strength can be established, it is clear that those properties which can be estimated from yield strength can also be estimated from tensile strength. As mentioned previously, however, it is customary to base all of these relationships upon hardness measurements.

Some parts can perform satisfactorily in service even though slightly distorted. In these cases the tensile or ultimate strength is often used as the significant strength in design. Since this property is determined under loading conditions equivalent to those under which yield strength is determined, however, the usefulness of tensile strength as a design property must be limited by the same factors which restrict the application of yield strength.

Furthermore, it must be recognized that tensile strength does not represent a true maximum stress at all. By the time conditions of maximum load are reached, the cross-section area of the stretched metal is so much smaller than it was originally that the true stress can be found only by dividing the load by the new cross-section area. The result is a true tensile strength considerably higher than the conventional value; furthermore, the highest true stress supported by the metal does not occur here but rather at fracture. The discrepancy between the conventional strength and true strength also holds for yield strength, but there the reduction in cross-section area is so small that the two values do not differ appreciably.

Since ordinary tensile strength is determined by dividing maximum supported load by original cross-section area, it is evident that the significance of ordinary tensile strength in design must be linked with load, not with stress. For example, a ½-in. bar made of steel having a tensile strength of 100,000 psi. could support a tensile load up to 20,000 lb. or 10 tons without fracturing. If the stresses in the bar were analyzed, however, it would be found that the actual stress at the minimum cross-section might be as high as 120,000 psi. In other words, tensile strength values can be used to predict maximum allowable loads, but provide an extremely conservative estimate of maximum allowable stresses.

Another factor which is sometimes important is the effect of time of loading upon tensile strength. There really is no such thing as *the* tensile strength, as a lower load applied for a longer period could prove to be the maximum allowable load. This phenomenon is called "creep," and is chiefly of interest for structures designed to operate at elevated temperatures where creep rates are significantly large. Even at ordinary temperature, however, there is a tendency for metals subjected to a steady load over a long period of time to be strained slightly even though no increase in load occurs.

From the foregoing discussion it might be assumed that the many limitations which must be observed in applying tensile strength values render these values virtually useless. But the questionable nature of tensile strength as a design property does not lessen its usefulness as an approximate index by which the strengths of different materials can be compared. Tensile strength can also be regarded as some indication of the allowable severity of hot and cold working processes. In general, a metal which is to be mechanically worked should have as low a yield strength as possible with high enough tensile strength to prevent local failures during forming.

Elongation, Reduction of Area

If a specified gage length is laid off on a steel bar before stretching it and the distance between the two marks is measured after fracture, it will be found that a measurable increase in length has occurred. This increase, divided by original gage length, is known as elongation and is generally expressed in percent. Obviously, elon-

gation is merely a special value of strain, namely, the total strain at fracture. Another property can be obtained by comparing the original and final cross-section areas. The difference between them, divided by original cross-section area, is known as reduction of area; it also is usually expressed in percent.

Elongation is quite sensitive to variations in test conditions, particularly in the size of the specimen. This is because, even disregarding end effects, elongation consists of two parts: (1) the uniform elongation which occurs over the whole specimen up to the time necking down begins; and (2) local elongation, which is a maximum at the center of the necked-down region and diminishes away from that point, gradually disappearing at a distance equal to several times the diameter for round specimens. The shorter the gage length used, the more pronounced the relative effect of localized elongation on total elongation and, therefore, the higher the elongation value. For the purposes of comparison, elongations, like yield strengths, mean little alone; the gage length used in determining elongation should always be specified.

Reduction of area is only slightly affected by the shape of the specimen. It is also unaffected by the length of the specimen, except where end effects become significant in short specimens. The usual standard specimen (2-in. gage length) is only a little short of the length beyond which such effects have no importance. Somewhat lower results for reduction of area can be expected from specimens having less than a 2-in. gage length.

In general, both elongation and reduction of area are more subject to variations in testing conditions than the other tensile properties. Variations from specimen to specimen and from point to point, and variation with direction in the same specimen are often considerable.

Variations in alloy content produce significant changes in both elongation and reduction of area. These two properties always change in the same direction and generally in a direction opposite to that of accompanying changes in yield or tensile strength. In other words, as strength increases, these two properties decrease, and vice versa. Elongation and reduction of area are particularly sensitive to small amounts of impurities in alloys. Minute amounts of oxygen, nitrogen or sulfur in steels can produce tremendous decreases in both of these properties.

Mechanical and thermal treatments also affect elongation and reduction of area in an opposite direction, compared to their effect on strength properties. A heat treatment which raises the yield strength of steel will simultaneously lower its elongation and reduction of area characteristics. In addition, these properties are lowered by any fabricating process which sets up stresses in more than one direction, such as welding.

Neither of these properties alone is useful in estimating any other common mechanical property of metals. An approximate method of estimating the Charpy impact strength of metals from tensile strength and reduction of area values has been worked out. In view of the generally mediocre reproducibility of the impact test, however, the accuracy, and thus the value of this relationship is open to doubt.

Elongation and reduction of area are generally used as indicators of the ductility (or ability to be drawn out) of a metal. As such, these properties have two distinct functions: (1) predicting the ability of a metal to be deformed without rupture by cold working processes such as bending, deep drawing, spinning and cold heading; (2) predicting the extent to which a part in service will deform under load before fracture occurs.

Some ferrous materials, such as gray cast iron, are hard but not ductile and cannot be easily fabricated. Lead and copper, on the other hand, are quite ductile but lack sufficient strength for many purposes. Since both fabrication and service must be considered, a good combination of strength and ductility in a metal is generally regarded as a fair indication of its suitability for engineering use. The fact that ductility usually decreases as strength increases means that obtaining a favorable combination of properties always involves sacrificing some of the strength and ductility inherent in the material.

The usefulness of elongation in predicting the formability of a metal has long been debated. There is evidence to show that straining during forming is not uniformly distributed and is often confined to an extremely small area. It is believed that the elongation over a gage length equal to the length of the bend or even approaching zero would provide a better basis for predicting sheet metal formability. Accordingly, increased attention is being devoted to the measurement of elongation over short gage lengths by means of grids. In addition, various "cupping" or simulated fabrication tests have been developed for predicting the behavior of a metal subjected to deep drawing.

There is also good reason to question the usefulness of elongation in predicting the service performance of a metal. Thus, 20% elongation is a common requirement for some metals even though few structural parts could endure such a large deformation and still function satisfactorily in service. There are some instances where large elongation values may be useful: (1) bolts, often overstressed in hand tightening, and (2) structures where the consequences of fracture are drastic enough so that some previous warning of impending failure is desirable. In general, however, 1 or 2% elongation is all that is required of most parts.

A certain amount of ductility is helpful in parts which contain a notch and are subjected to repeated loading, as the effects of stress concentration at the base of the notch are diminished. Since this deformation occurs in a highly localized region, the conventionally determined values of elongation are not strictly applicable. Furthermore, it is unusual to find any dimensional change in a part which has failed after repeated loading as high as the 10 to 60% commonly found in the tensile test for ductile metals. The brittle conditions developed under these circumstances are not revealed by the normal indexes of ductility.

There is no question that the importance of elongation and reduction of area has been greatly exaggerated in the past. For instance, engineers have found it possible to replace ductile materials by seemingly brittle materials in parts subjected to repeated loading. One example is the use of gray cast iron in crankshafts, where malleable iron was formerly used.

In general, it can be said that elongation and reduction of area give a rough picture of the ductility of the metal. They should be used, not as design properties, but as rough guides in the selection of a material.

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Metal Powder Parts Successfully Plated by New Process

The "spotting-out" condition encountered in electroplating porous metal compacts can be eliminated in many cases by methods described here which involve heat treatments to remove residual plating salts.

by **JEROME F. KUZMICK**, Manager, Ekstrand & Tholand, Inc. Powder Metallurgy Laboratory

● THE SURFACE TREATMENT of metal powder parts to make them corrosion resistant represents a rather difficult problem, primarily because such parts are porous. Frequently porous parts are impregnated with oil to make them self-lubricating. In the case of ferrous powder parts, the oil tends to inhibit rusting to some degree, particularly in gears and bearings which rotate against a mating part. However, in many structural parts it is desirable to avoid oil impregnation. When exposed parts require a pleasing appearance, such as in typewriters and office machinery parts, a more positive and attractive rust-proof coating is desirable.

Ferrous powder parts are sometimes given standard black oxidizing treatments, such as exposing heated parts to air, then oil quenching. Lenel[1] and Spangler[2] have described the steam treatment of iron powder parts to black oxidize their surface. However, such blackening treatments have three drawbacks. (1) Often a light rather than a black finish is desired; (2) the part is weakened and embrittled because the interior is also oxidized; and (3) even such oxidized parts may rust in time due to pore surfaces which may not be completely oxidized.

Plating Problems

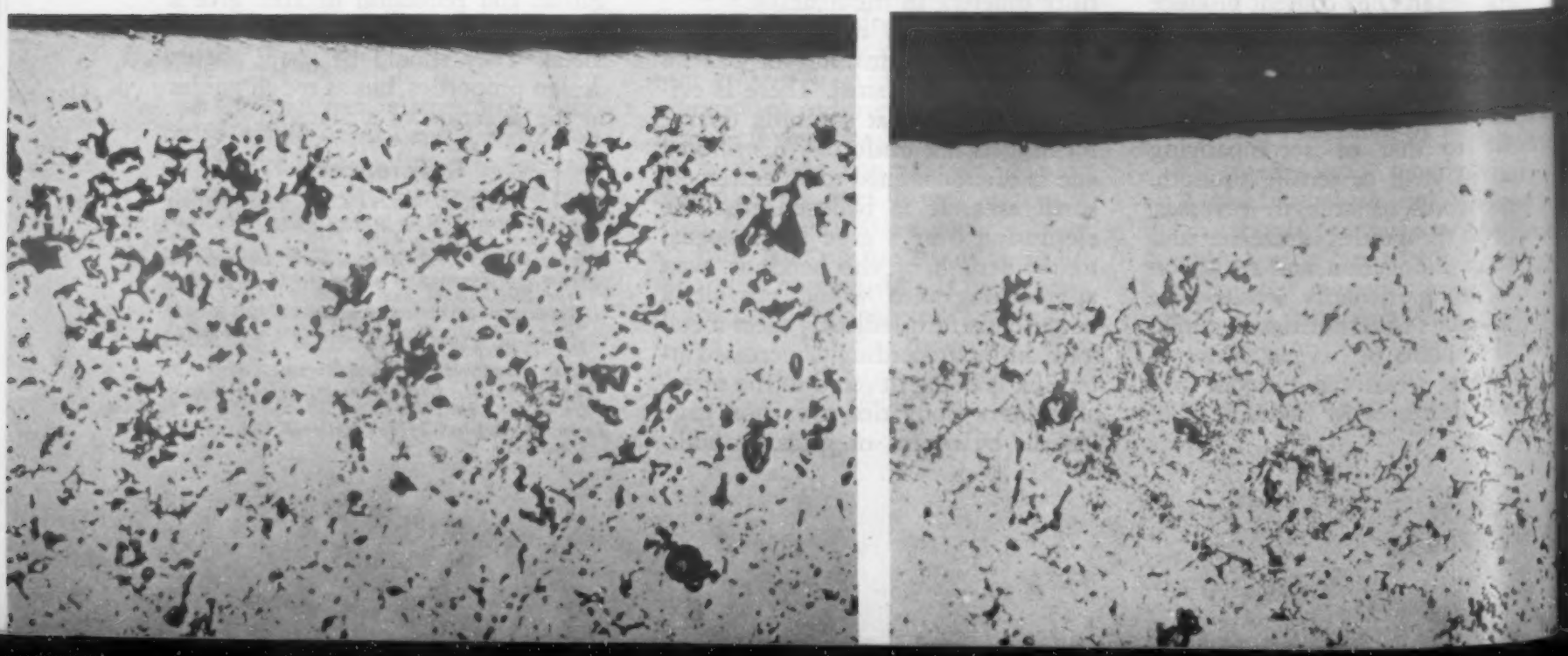
A satisfactory method of electroplating porous metal powder parts to endow them with a corrosion resistant surface and/or a bright pleasing appearance is often demanded. However, the plating of such parts involves the following special problems.

(1) Pressed and sintered parts have a velvety rather than a glossy finish, due to their irregular surface. The surface porosity makes it difficult to obtain a uniform deposit of plating metal. This condition is minimized on parts which have been repressed or tumbled after the sintering operation.

(2) It is very difficult to completely seal the surface of such parts by plating them. A satisfactory looking coating is no guarantee that corrosion or rusting will not occur in porous spots which may absorb moisture or harmful vapors from the atmosphere.

(3) The most serious problem of all is interior corrosion caused by entrapped liquids or salts from the electrolyte. During the plating operation, the porous part acts as a sponge and soaks up electrolyte until the interior is completely saturated. Thereafter, it is impossible to completely remove this entrapped electrolyte by ordinary means. Often this entrapped salt or acid begins corroding the interior of the part within a few days. As time goes on, this corrosion works its way to the surface and erupts into a series of spots. The part may be so weakened by interior

Fig. 1—Photomicrographs of two porous iron compacts, presintered, electroplated with 0.001 in. of nickel, then sintered 10 min. (left) and 30 min. (right), respectively, at 2000 F. (400X)



corrosion that it is worthless, and it would have been better had the part not been plated at all.

This condition, commonly called spotting-out in the trade, has long been recognized and various attempts have been made to overcome it, such as repeated washings in circulating hot water, etc. However, the author has boiled nickel-plated porous iron parts in water for as long as 24 hr., and has still observed spotting-out in some areas a few weeks later.

Anderson[3] has recently prescribed certain procedures in the preparation of brass powder parts for plating. Undoubtedly, the procedures described are valuable in obtaining a satisfactory surface coating. However, it is felt that the seriousness of the spotting-out problem has been minimized. It is true that certain electrolytes, such as chromic acid solution, are not as corrosive as others. It may also be true that spotting-out is not as serious with nonferrous alloys such as brass. However, with sintered iron parts this usually represents a disastrous condition.

Over the past few years a proprietary method, called Etolizing, of electroplating porous metal powder parts has been developed at the Ekstrand & Tholand Powder Metallurgy Laboratory, which has been applied with good success. This process eliminates the spotting-out condition. The method is based on the principle that the residual plating salts are volatilized out of the pores by heat treatment, in contrast to the usual method of washing out such salts by solution in hot water or some other solvent.

The process has been successfully applied to coat porous iron, brass and bronze parts. Coating metals have included copper, nickel, silver, copper-nickel and copper-tin. Chromium is satisfactory provided a very dry atmosphere is used during heat treatment.

At first it was felt that the process would be restricted to plating metals with melting temperatures above 1000 F. However, recent tests have indicated that porous parts which have been nickel- or copper-plated, then sintered to seal the surface, can finally be plated in the usual way with such metals as cadmium or zinc, without further heat treatment.

Description of Process

In the heat treatment of porous plated parts, certain of the plating salts are readily volatilized out of the porous compact, particularly in the reducing atmosphere usually employed in sintering operations. Other salts, particularly cyanides, are not readily volatilized by the application of heat. In the latter case, immersion of the compact in a neutralizing acid, preferably an organic acid, will convert the salt to a readily volatilizable compound, which is then removed by heat treatment.

In practice, the three methods of Etolizing shown in the accompanying table have been used. Method 1, of course, is only applied to racked parts which have sufficient green strength to permit handling. It usually cannot be used for barrel plating, because most unsintered parts would show cracks or frayed edges as a result of barrel tumbling. The advantage of Method 1 is that no additional sintering operation is required.

Method 2 is good for all types of plating, rack, barrel, etc., on thin section or heavy section parts. At first glance, it would appear to be more costly than regular plating and washing, because of the additional pre-sintering operation. In actual practice, however, it has often been found that with a furnace atmosphere which produces bright clean work, the pre-sintering operation replaces the usual degreasing, pickling, neutralizing and washing operations. This more than offsets the cost of a short pre-sintering operation. It has also been found that the clean surface obtained from the pre-sintering operation eliminates the need of a preliminary flash coat. A very satisfactory plating of a metal such as nickel directly on iron is obtained.

Methods 1 and 2 result in a dense coating which shows good corrosion resistance with a coating metal such as nickel, because of the final sintering operation. It is believed that the mechanism which brings this about operates as follows. The piece as plated will show surface porosity. As the temperature of the compact begins to rise in the sintering furnace, residual electrolyte salts volatilize out of the compact through the surface pores. At this point the surface porosity of the compact may actually increase. Finally, during the full time and temperature of sintering, surface pores disappear due to the sintering action, and some diffusion of the plating metal into the surface of the compact may take place. This is shown in Fig. 1. The 60-min. sinter has diffused the nickel to give a depth of penetration about twice that of the original coating, as shown by the 10-min. sintered sample. However, even the latter has a dense solid surface.

Method 3 is particularly adaptable for parts which are to be oil im-

Methods of Plating Metal Powder Parts

METHOD 1

A "green" unsintered compact is electroplated, washed, given the neutralizing acid dip if required, then sintered in the usual manner.

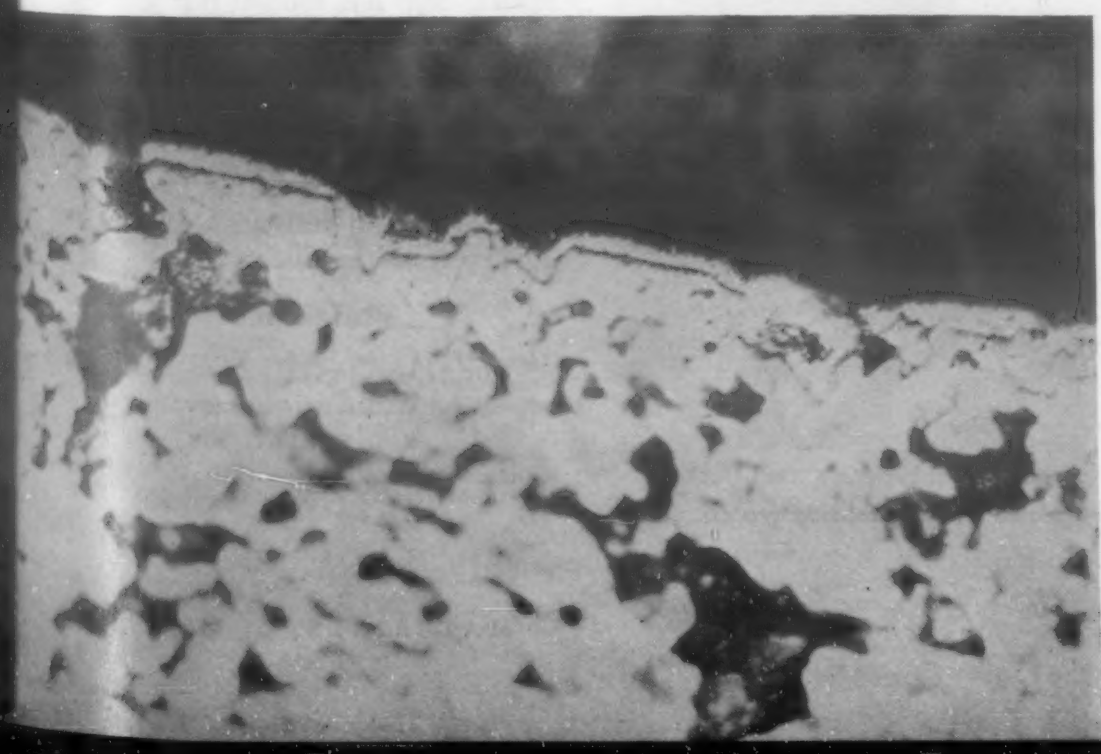
METHOD 2

A "green" compact is given a short preliminary pre-sinter to increase its handling strength and clean its surface, then electroplated, washed, acid dipped if required, and finally subjected to the full sintering operation.

METHOD 3

A fully sintered part is electroplated, washed, acid dipped if required, then given a short heat treatment to volatilize residual salts out of the pores.

Fig. 2—Photomicrograph of a silver plated iron porous bearing.

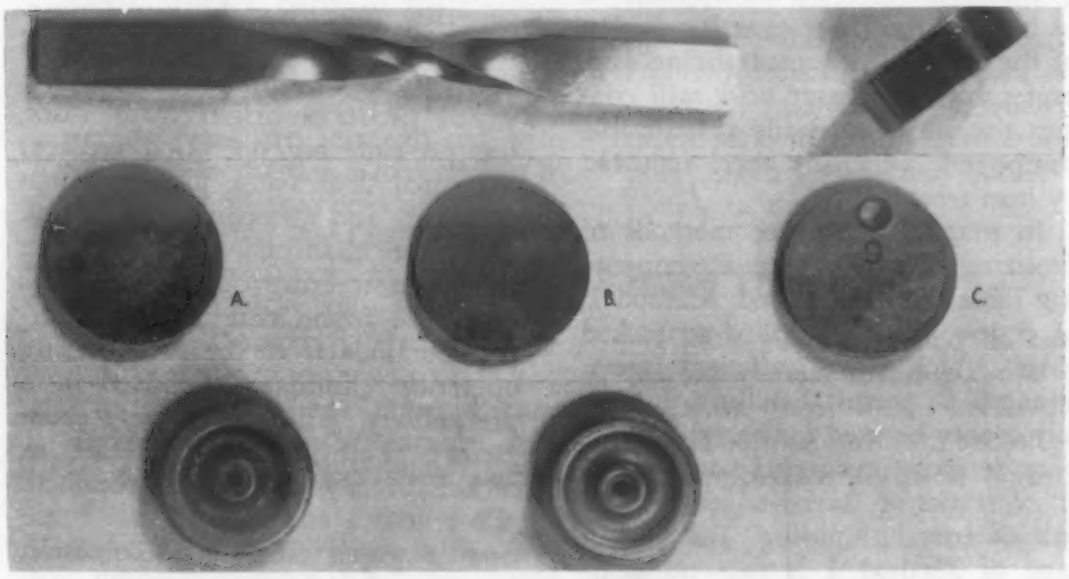


pregnated for self-lubrication, since the final heat treatment can be short enough so that the surface porosity can be preserved to permit oil penetration. Oil-filled plated parts have good corrosion and rust resistance, with the proper plating metal, despite surface porosity. The exposed surface and outer pore surfaces are protected by the plating. The interior pores are protected by the oil and, of course, no residual salts remain in the pores to cause interior corrosion. The photomicrograph in Fig. 2 illustrates this method. A sintered iron-graphite porous bearing material was plated with 0.0005 in. of silver, washed, acid dipped and given a 15-min. heat treatment in dissociated ammonia atmosphere at 1500 F, then oil impregnated.

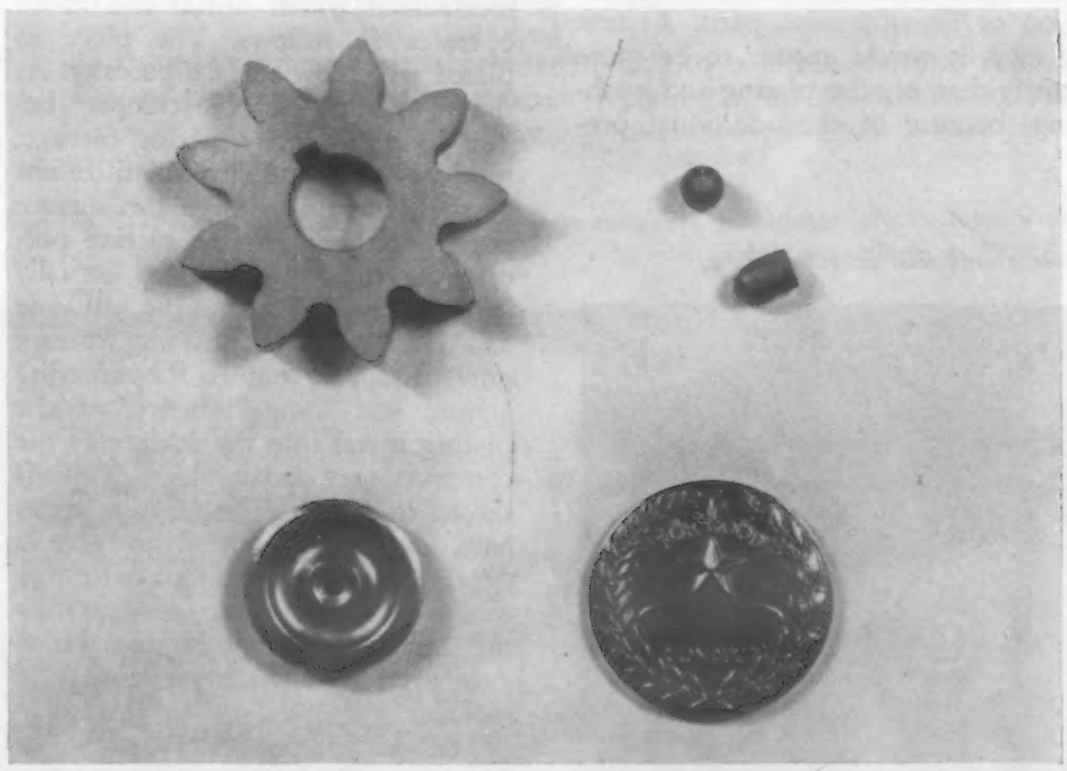
On solid pieces, one might expect blistering if such heat treatments are applied after the plating operation. However, plated porous metal powder parts passed through the normal preheat, hot and cooling zones of a sintering furnace show no signs of blistering. The gases escape through the surface pores before final sealing of the surface coating takes place.

There are incidental advantages which accrue from the heat treating operation subsequent to plating. The heat treatment removes occluded gases and firmly bonds the coating to the part, resulting in an annealed, soft, adherent coating. Parts can be given a final sizing or coining operation without disrupting the plated surface, resulting in plated parts of close dimensional tolerance.

Parts coined to high density give a smooth surface coating which can be polished to a high luster. It is also possible to promote alloy surfaces. For example, parts have been plated with layers of nickel and copper, and copper and tin, then heat treated at sufficient time and temperature to diffuse the surface layers. The resultant coatings are Monel and bronze, respectively.



Nickel-plated iron powder parts showing the improvement in corrosion resistance by heat treatment after plating.



Typical appearance of parts that have been plated by the Etolizing process.

Typical Applications

An accompanying figure shows a nickel-plated, heat treated and twisted iron bar, and an iron cylinder which was coined to high density after it had been nickel-plated and heat treated. In the center are three disks which were subjected to a standard 72-hr. salt spray test. All are sintered iron, and all were nickel-plated in the same manner. In the figure, A was given the ordinary hot water wash after it had been plated, and shows severe corrosion; B was given a 30-min. heat treatment at 2000 F, to promote a sealed surface; and C was given a 15-min. heat treatment at 1500 F, then oil impregnated. Both disks, B and C, show no corrosion. At the bottom of the figure are two toy iron wheels, both nickel-plated at the same time under the same conditions. The one at the left was washed with hot water, the one at the right was heat treated. Both have been aged under normal room conditions for two years. The one at the left shows typical spotting-out. The heat treated wheel is clean.

A variety of finishes are available, depending upon the treatment given to the part. A regular plated, heat treated, sintered piece will have a dull, clean, velvety finish which is quite pleasing in appearance. A part tumbled or burnished before the plating and heat treatments will have a fairly glossy surface. If such parts are given a final polishing operation, they will take on a high gloss.

An accompanying photograph shows a pre-sintered, tumbled, nickel-plated, heat treated iron toy wheel; a porous sintered iron gear, nickel-plated, lightly heat treated, then oil impregnated; a brass medal, sintered, burnished, silver-plated, heat treated, then polished. Also shown is a sintered iron bullet, copper-plated and heat treated, which on test has shown good corrosion resistance as well as low wear on the rifle barrel.

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Selecting Steels and Heat Treatments for Automotive Gears

True economy in production of gears requires careful consideration of a great many factors, the most important of which include cost of steel and heat treatment.

by V. E. HENSE, H. H. MILLER and R. B. SCHENCK,

Buick Motor Div., General Motors Corp.

• THE OBJECTIVE OF THE engineer is to design and specify a gear for an application that will produce the required quality at the lowest possible cost. The proper selection of steel and correct processing methods, taking into consideration ease of fabrication, are absolute necessities for true economy.

The design of a gear and the demands of operation are important factors, influencing economy in the selection of steel and the heat treatment. The demand for quietness of operation of the modern automobile has made it necessary to go to great lengths in securing steels of adequate machinability to meet gear tooth finish requirements; at the same time, heat treating operations have been improved to secure the required dimensional uniformity.

The cost of the steel for a gear is an important item in the total cost of the part. From one composition to another, the amount and type of alloy generally determines the difference in cost. Inherent qualities of each steel, such as uniformity of hardenability, distortion characteristics, and machinability, must be considered at the same time that the cost is considered. Availability of a material and the ability of a mill to divert off-heats are important considerations in selecting a steel.

A correctly applied steel must be capable of satisfying all requirements of the application, taking into consideration the variation in hardenability that must be expected. This refers not only to properties that are developed in the finished part, but also to properties that must be developed for processing needs. The choice of a steel for a specific gear application is made primarily to furnish the required properties in the finished part. However, it is also necessary to specify a material that can be processed to production requirements.

Therefore, it is necessary to consider the processing characteristics. The steel must fit into available facilities, or savings should justify the purchase of new equipment. The steel should satisfy the conditions of manufacture over the entire range of properties that must be accepted under the specification.

This article is divided into two parts. In the first part, economy in selection of a steel for automotive gear applications is discussed; and in the second part, factors influencing the economics in the selection of heat treatments are presented. The discussion is limited to the practice used for rear axle, transmission (conventional, semi-automatic and automatic), and flywheel ring gears.

Selection of Gear Steel

A steel should be selected that fulfills all requirements of an application at the lowest cost. The proper choice can be made only when the engineer understands all conditions of manufacture. The requirements are dictated by the design, application, and quality level. The normal variation in the steel must also be taken into consideration.

Characteristics of a steel that influence economy are availability, cost, machinability, heat treating qualities, performance properties, and uniformity.

Availability—A steel must be available in sufficient quantities to fulfill production requirements, and the limits of manufacture must satisfy the demands of the application. Critical requirements caused by design or quality demands may make it necessary to restrict the specification and thus increase the cost. If a particular specification has little use, it may be difficult to secure required qualities with suitable delivery.

There are many steels covering a wide range of properties available to choose from for automotive gear applications. A survey among manufacturers has shown considerable variation in the selection of steel for each gear application. For rear axle gears the following SAE steels are used: 1016, 1019, 1022, 1024, 4024, 4028, 4032, 4620, 4620H, 5120, 5130, 8615, 8617, 8620, 8620H. For transmission gears the following steels are used: 1024, 1320, 1340H, 4032, 4640H, 5135H, 5145, 8620.

Cost—The base cost of the steel, in comparison with that of equivalent grades, is an important consideration in the selection. Cost of a gear is made up of the steel cost plus the

cost of manufacturing. It is not possible in a discussion of economy to view steel cost without considering effects upon subsequent manufacturing operations. Any increased cost of one grade over another must be warranted by a necessary quality improvement or greater economy in processing. Justification of a steel on the basis of decreased processing costs is often quite difficult because of intangibles involved. Items of cost in processing, such as tools, repairs and scrap, can be evaluated only if adequate records are available for long production runs.

Machinability—The steel selected must be capable of being machined to quality requirements at the specified production rate with a reasonable tool cost. Differences in inherent machinability between one specification and another should be considered before a choice is made. If available annealing cycles are inadequate for producing a structure with the required machinability, sufficient decrease in steel cost must be present to allow for the purchasing of necessary equipment.

Machinability is generally measured in terms of surface finish and tool life. On applications such as hypoid gears, where excellent tooth surfaces are necessary, finish is a controlling factor. Where surface smoothness is readily obtained, as in the shaving operations on transmission gears, tool life is the important consideration. In each case, however, the tool cost is a factor influencing economy.

Improvements in machinability that allow reductions in labor through greater speeds and feeds are most easily recognized. At equivalent production rates and quality, cost is affected only by tool life.

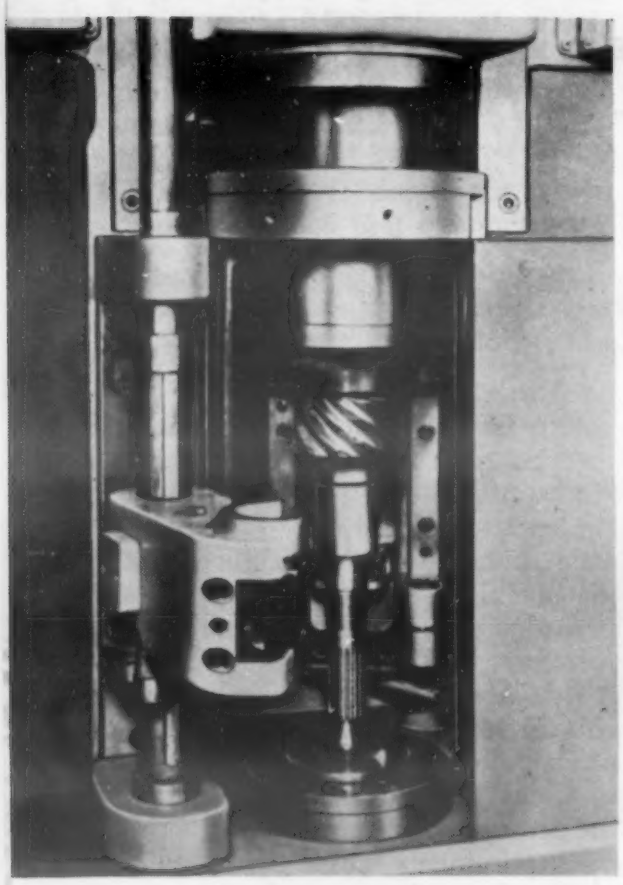
Sometimes improved machinability justifies the added cost of a sulfur addition in the steel. A sulfur addition may improve economy not only in its desirable effect upon finish, but may allow the production of greater tooth accuracy and less stress from machining. Sulfur additions which have proved beneficial to many other applications are not extensively used in steels for highly stressed gears.

Heat Treating Qualities—The heat treating characteristics of a steel must allow the securing of the specified properties throughout the range of chemistry and hardenability. If the demands of operation or processing are such that the full variation of a specification will not produce satisfactory heat treating conditions, it is necessary to restrict the acceptable limits at an increased cost or be able to divert extreme heats to other applications. With some designs, difficulty may be experienced in securing satisfactory results at the minimum and maximum extremes of a specification. Difficulty with distortion, causing erratic tooth changes and increased straightening costs, are common at the high side of specifications, while unsatisfactory response in securing the necessary properties may occur with low hardenability heats.

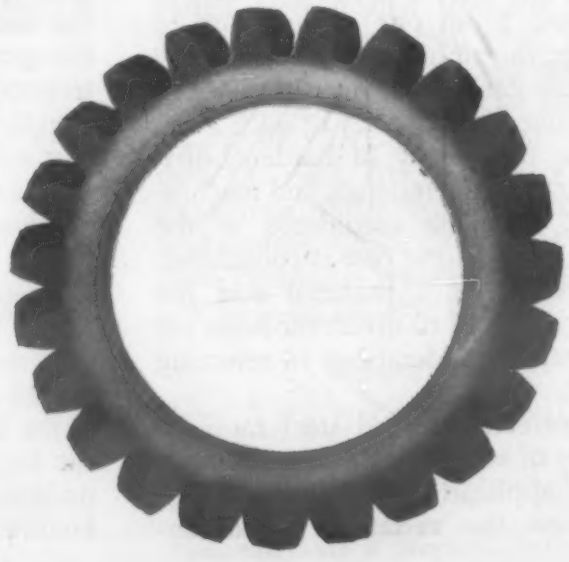
On jobs with critical requirements, it is often necessary to exert extra care and control in processing. Production pilot lots are used in addition to laboratory acceptance tests in determining if high and low hardenability heats of steel will produce satisfactory results. Any narrowing of hardenability bands is a step toward more desirable production conditions and decreased manufacturing cost.

Performance Properties—Usually there is little choice between steels of equivalent hardenability in their effect upon final operation of the gear,

Shown here is a rear axle drive pinion in quenching position in quenching machine. (Courtesy Gleason Works)



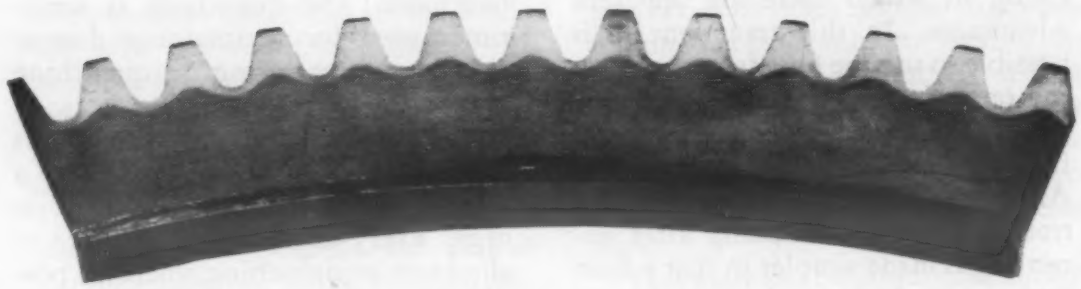
Reaction gears, such as the one shown at left, are induction hardened. Right, cross section through induction hardened area of gear.



Left, counter gear showing pitting on teeth; right, surface of badly pitted tooth on low-speed step of counter gear.

but where the design or application is such that the selection is made because of service characteristics, economy is affected. Such items as slight differences in wear resistance, toughness, or uniformity might become important considerations where design and application are critical. Steels that prove unsatisfactory generally fail in processing rather than in service requirements.

Uniformity—In the production of gears with great demands for interchangeability and a high production rate, uniformity is very important. Any improvement in uniformity of properties of one material over another cannot be overlooked as a factor influencing economy.



Cross section of induction hardened flywheel ring gear.

Selection of Heat Treatments

Two general factors of cost must be considered in the selection of a heat treatment for automotive gears. The first is the economy of the operation itself, and the second is the effect upon subsequent processing.

Items affecting economy in the heat treating operation are equipment, labor, operating and maintenance costs. Additional factors are expense of idling equipment during down time and control cost. Equipment is selected primarily to produce the required results at the specified production rate. The trend is to continuous automatic equipment that furnishes uniform results at the minimum labor cost. Whether the fuel should be oil, gas or electricity is a function of the cost of the fuel in the area of production. Choice of fixtures, refractories, and other maintenance items are somewhat regulated by the temperatures involved. The size of the equipment is determined by the production rate and the flexibility of operation desired.

Because the gear is changed during heat treatment both in properties and dimensions, the effect upon subsequent processing must be considered. Changes in dimensions, which are referred to as distortion or movement, must be uniform in nature in order that preventive corrections can be made in machining. Control of physical properties is very important in annealing cycles or in quench and temper cycles where heat treatment is followed by machining. Non-uniformity in heat treating adds up to increased cost from straightening, repairs or scrap.

Annealing—Annealing is applied to automotive gears for producing a structure for satisfactory machinability and to relieve stresses which might cause distortion in subsequent operations. Machinability is measured in terms of finish and tool life. Continuous equipment is commonly used for annealing automotive gears. Factors influencing economy in annealing are labor cost, operating cost, maintenance cost, and the effect on

cleaning operations. The method should be flexible, allowing changes to be made for steel variation.

In the annealing of rear axle gears, the development of a structure which will furnish the required smoothness of finish for tooth surfaces is the important consideration. Because of the expensive tooling and long setup times involved, machinability influences economy of processing to a great extent.

Three general methods are in use for rear axle gears. They are cycle annealing, the normalizing, and isothermal transformation from the forging operation. From the cost standpoint, cycle annealing and the normalizing are about equivalent. A higher head temperature may increase maintenance costs, but generally slight variations in economy of operation are not important if improved results in machining or subsequent heat treatment can be realized. A normalizing or cycle annealing furnace can be operated with the same labor cost.

A newly applied anneal, using the forging heat and transforming in salt at 1190 F, offers a variation in processing in which there are apparent advantages. In this treatment it is possible to use the heat from the forging operation, to eliminate handling, and at the same time secure a structure which has good machinability. Another advantage of this type of treatment is that descaling after annealing is made simpler in that a flash water quench from the transformation temperature loosens the scale. These advantages must be weighed against the cost of operation of the salt bath.

The prime requisite in the annealing of transmission gears is to secure a structure which will satisfy the varied machining operations at an acceptable tool cost. Broaching, turning, milling, drilling, hobbing and shaving operations are included in the manufacture of transmission gears. It is sometimes necessary to produce a structure that will favor a broaching operation and, consequently, penalize turning operations. For instance, if finish requirements or design of a part makes the broaching operation critical, a harder structure is desirable. Tooth finish is readily controlled with shaving operations.

Hardening—In the hardening of automotive gears, it is desirable to produce the required physical properties with the least dimensional disturbance. Distortion can be caused by stresses from machining, non-uniform heating and carburizing, and variation in the hardenability of the steel.

Of the many factors involved in securing uniformly heat treated parts, the quenching methods have probably been neglected the most. It is common practice to quench dense loads of gears in circulated oil at temperatures ranging from 100 to 130 F. With such practice, distortion can be held to close tolerances only with great difficulty. Excessive distortion of gear teeth and shaft dimensions, along with non-uniform changes in ID dimensions, are major problems for the plant striving for a uniform end product. Where such distortion becomes unbearable, it is often economical to incorporate a hot quench with either an oil or salt quenching medium. Such cycles, although minimizing distortion, do not eliminate it. Since hot quenching treatments, at the present time, are generally more costly than the conventional quench, the improvement in uniformity must be balanced against the increased expense. Unless considerable scrap or rework is eliminated, it is often impossible to justify a hot quenching treatment. Die quenching is sometimes used for maintaining dimensional accuracy during the quenching operation.

After hardening, straightening is sometimes necessary. This is not a desirable operation and the cost is high. Every effort should be made to eliminate straightening wherever possible.

Carburizing—The practice in the carburization of rear axle ring gears is quite uniform throughout the automotive industry. Gas carburizing is most popular, with some carbonitriding and pack carburizing being used. Case depth practice for ring gears and drive pinions is quite uniform among manufacturers, with some variation in the treatment of side gears and side pinions. Oil is used predominately as the quenching medium. Rear axle ring gears are die quenched to maintain the flatness of the back face and the roundness of bore. Drive pinions are mass quenched from the carburizing operation by some manufacturers and singly quenched by others. Buick is installing die quenching machines for drive pinions. The practice in the tempering of rear axle gears varies, and some manufacturers have no tempering operation. One manufacturer removes the part from the quenching press while it is hot enough to produce a tempering effect.

In the manufacture of automatic transmission gears, it has been necessary on some applications to go to great lengths in the selection of heat treatments in order to provide the necessary accuracy and uniformity. Selective hardening of gear teeth and hot quenching treatments are being used extensively. Design has influenced the application of heat treatments to a great extent. Some designs are of a nature that demand selective hardening, not only for maintaining tooth accuracy, but also because parts could be furnace hardened only with great difficulty.

Hot quenching operations are being carried out with either salt or coil as the quenching medium. Some hot quenching is being done in continuous furnaces where the quenching unit is conveyorized, while in other applications the parts are heated in continuous furnaces and batch quenched.

Probably the most significant move in the heat treatment of transmission gears has been the development of continuous gas carburizing or carbonitriding equipment. This equipment has been applied quite generally over the last 15 years, and has probably been the greatest single contributing factor to the uniformity of heat treatment of transmission gears. Uniformity of heating and quenching, flexibility in controlling case compositions, and high production are typical advantages of this heat treating equipment. Continuous heat treating usually proves most economical from the labor standpoint. In selective hardening or batch type hot quenching, the parts heat treated per man-hour are generally decreased considerably. For example, on one job where a part was changed from a continuous furnace operation to a rotary furnace with a batch quench in molten salt, the gross production was decreased from 370 parts to 159 parts per man-hour. This particular move was made to reduce rework and improve quality, but the labor cost was more than doubled.

In the selective hardening of gears, production rates of slightly over 100 pieces per man-hour are typical. If such parts could be hardened continuously, the production rate could be greatly increased with a corresponding labor saving. Therefore, if possible, parts should be processed in continuous equipment.

This article is based on a paper presented at the Summer Meeting of the Society of Automotive Engineers, June 4-9, 1950.

New Aluminum Alloy Offers High As-Cast Properties

Use of high-purity aluminum results in a corrosion resistant casting alloy with exceptional strength, ductility and machinability without need for heat treatment.

A NEW MATERIALS PREVIEW

• A HIGH-STRENGTH ALUMINUM casting alloy of particular interest to the small fabricator who does not have elaborate heat treating equipment is now available. The aluminum-magnesium alloy has unusually good as-cast strength and ductility, thus eliminating the need for expensive heat treatments to improve properties. It has already replaced gray cast iron and malleable iron in a number of applications where its high machinability, good finish or light weight offered special advantage.

Named Almag 35, the alloy is being marketed by William F. Jobbins, Inc. It derives its high as-cast properties primarily from the use of high-purity (99.8% or better) aluminum and a magnesium content of 6.5 to 7.5%. There are also small amounts of other alloying elements, though only titanium and manganese are present in excess of 0.1%. A fractional percentage of beryllium is included to control oxidation. Impurities are held to an absolute minimum —typically, silicon to 0.08% and iron to 0.10%.

Properties

The following data give a fair indication of the properties that can be expected in normal operation: tensile strength—37,000 to 42,000 psi.; yield strength (0.2% set)—17,-500 to 20,000 psi.; and elongation (in 2 in.)—10 to 15%. It should be pointed out, however, that these results were obtained on castings produced from large heats containing as much as 40% scrap. Field reports indicate that these properties are being exceeded in many cases.

Some typical mechanical, physical and electrical properties of the sand-cast alloy are listed in Table 1. In general, the mechanical properties are believed to be on the conservative side. These properties remain practically constant from —76 to +225 F. This is due to the high dimensional stability made possible by almost complete absence of reprecipitation. Even at higher temperatures, growth of this alloy is less than one-third that of alloy 356. Nevertheless, Almag 35 is not recommended for high temperature use, nor should it be used for pressure applications.

The main advantage of this alloy is found in the fact that its favorable properties are developed immediately upon solidification of the casting. The lack of need for heat treatment removes the possibility of warpage and also the occurrence of residual internal stresses resulting from the quenching operation. Such stresses are believed to be the cause of fatigue failures of many castings produced from heat treated aluminum alloys. In addition, Almag 35 castings retain their original properties, whereas the properties of other high-strength aluminum alloys change to varying degrees as a result of age hardening. Not the least consideration is the elimination of heating costs and possible production bottlenecks, with resulting savings for fabricator and consumer.

This alloy can be rapidly machined; despite its high ductility there is no tool drag. A comparison of milling speeds, as presented in Table 2, shows that Almag 35 has about four times

A typical large casting made of the new aluminum-magnesium alloy.

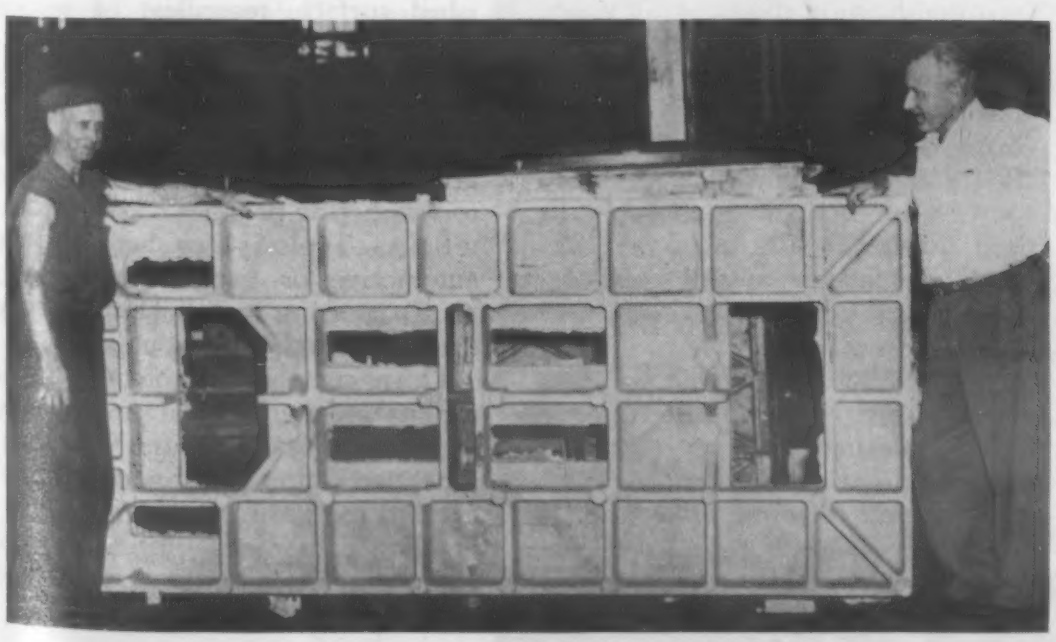
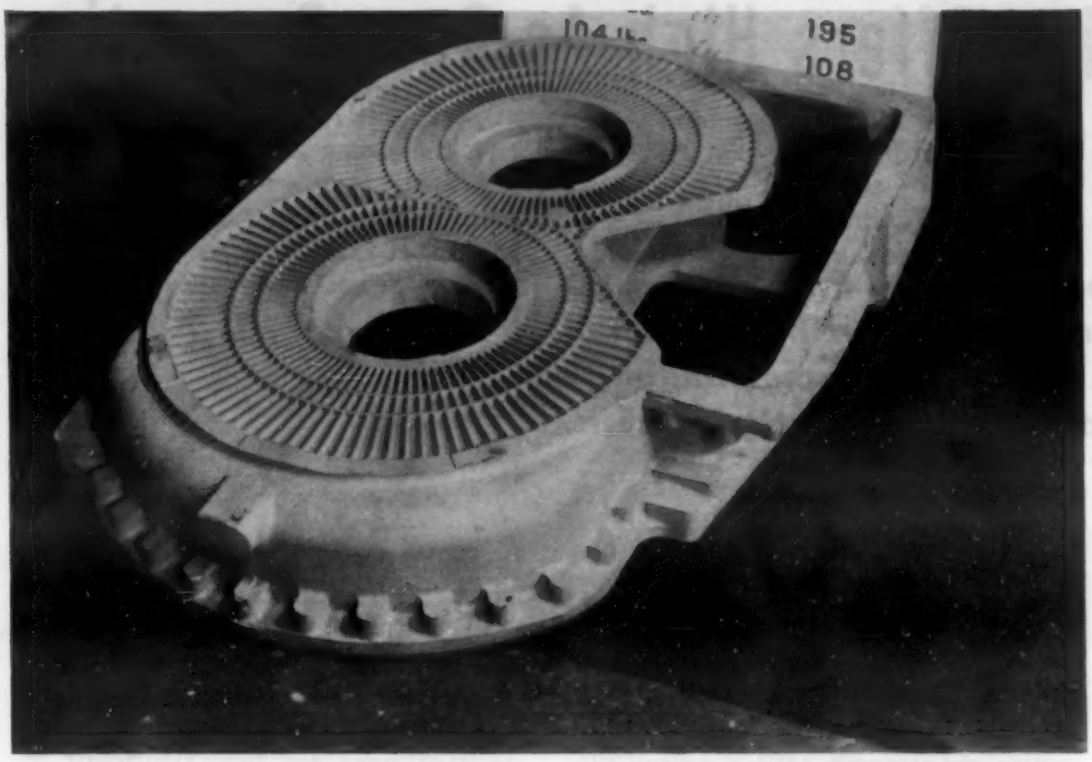


Table 1—Typical Physical and Mechanical Properties of Sand-Cast Almag 35

Ultimate Tensile Str., Psi.	40,000
Yield Str. (0.2% Set), Psi.	19,000
Elongation, % in 2 In.	13.0
Brinell Hardness	70
Notched Charpy Impact Strength, Ft.-Lb.	6
Endurance Limit, Psi.	10,000
Modulus of Elasticity, Psi.	10.3×10^6
Electrical Resistivity at 68 F, Microhm-Cm.	7.42
Electrical Conductivity, % by Vol. of Copper Std.	23.2
Coeff. of Exp. per deg. F:	
—76 to +68F	1.20×10^{-5}
68 to 212 F	1.31×10^{-5}
68 to 392 F	1.42×10^{-5}
68 to 572 F	1.48×10^{-5}
Density, Lb. per Cu. In.	0.095
Solidification Range, F	1165-1020



Elimination of the need for heat treatment on large Almag castings such as this remove possibility of warpage.

A group of parts showing the variety of castings for which Almag 35 is suitable.

the milling speed of alloy 108 and 16 to 18 times that of gray iron and malleable iron. In many cases, this tremendous saving in machining, compared to cast iron and malleable, has offset the higher cost of the rough casting and resulted in lower cost per finished part.

Another advantage related to good machinability is the highly reflective surface produced by high milling speeds. By means of recommended compounds, this machined surface can be buffed and polished to a mirror finish. This is an important factor, as the sales appeal of cast products often depends primarily on surface appearance.

The corrosion resistance of Almag 35 is claimed to be higher than that of any other aluminum alloy. Its good durability is attributed to the almost complete absence of heavy metal alloying elements which induce electrolytic corrosion, and to the relatively high content of magnesium which gives it further protection against corrosion by mild alkalis or salt spray. It is also more easily anodized than other high-strength aluminum casting alloys; this treatment not only increases its corrosion resistance but also produces a pleasing appearance and is quite resistant to abrasion. In rigid laboratory tests, Almag 35 has shown no tendency toward stress corrosion.

Because of its high resistance to corrosion, this alloy generally does not require any further surface treatment. If desired, however, it can be satin anodized or chromium plated for additional corrosion protection. It can also be anodized in true rich colors, opening up new applications in the ornamental field. Since silicon is present only as an impurity, the discoloration it usually causes in anodizing does not occur.

The availability of this alloy has solved at least two specific materials problems. Before the development of Almag 35, the most commonly specified aluminum casting alloy for shock resistance was 195 heat treated. It has a Charpy impact value of 1½ to 3 ft.-lb., but is not a stable alloy. Almag 35 offers stability and a typical impact strength range of 5 to 6½ ft.-lb.

The high ductility properties characteristic of Almag 35 were formerly obtainable only through sodium modification of an aluminum-silicon alloy. Not only did this treatment produce erratic results and tend to decrease castability, but the improved elongation was gained at the expense of other properties.

In addition, the low specific gravity (2.62) of Almag 35 offers economies amounting to 1 to 2¢ per lb., compared with aluminum-copper and aluminum-magnesium-zinc alloys. The weight advantage gained by substituting this alloy for cast iron or malleable is considerably greater and is reflected in savings in handling and shipping costs.

Table 2—Comparative Milling Speeds

Material	Surface Ft. per Min.*
Gray Iron	225
Malleable Iron	250
108 Aluminum Alloy	1000
Almag 35	4000

** Based on use of carbide tools under optimum conditions.*

Applications

The unique combination of properties found in this alloy suggest a wide variety of applications. In addition to the sand casting alloy, special modifications are available for permanent mold and die castings. Prices may vary widely with the nature of the part to be cast, but probably average about 22 to 23¢ per lb.

Almag 35 seems particularly suitable for ornamental castings because of its mirror-like finish when polished. Since it is a solid-solution alloy, it does not show pinholes on the polished surface, regardless of section thickness. This is not true of eutectic-forming alloys such as 355, 356, 319 or 108.

Its high corrosion resistance suggests its application to parts subjected to weathering or other corrosive conditions. Typical uses here include automotive or marine parts, hardware, sporting goods, architectural ornaments and cooking utensils.

Other current and potential applications are agricultural implements, armament, cast furniture, diesel engine parts, fire fighting equipment, garden tools, highway trailers, hydraulic equipment, machine tool equipment, mining equipment and textile machinery.

Brazing and Soldering of Metals Accomplished by Induction Heating Methods

For many soldering and brazing applications where medium and small lot production is involved, high frequency induction heating can often result in savings in processing costs.

• THE BRAZING and soldering of piece parts into finished assemblies was long performed exclusively by either torches or furnaces. These techniques are still widely used, and furnace brazing, in particular, has an accepted place where the quantity of parts and their size justify this approach. Torch heating, though it requires a skilled operator and normally permits only single-piece processing, also is indicated for certain applications.

In recent years, high frequency induction heating has won increasing industry acceptance because of its ability to heat selected portions of metal parts rapidly to practically any temperature, its cleanliness and absence of flame, and the flexibility with which it can be applied. For a wide range of soldering and brazing applications, particularly where medium and small lot production is involved, these features of induction heating, and the relatively unskilled help required, have resulted in savings in processing costs which can seldom be approached by other methods.

High frequency induction heating is capable of rapid heating of metals which, particularly in the case of brazing, results in speedy processing of an assembly. With the short time intervals and not too high temperatures involved, very little if any oxidation and warpage of the part can take place.

Induction heating makes possible selective heating of just that part of an assembly which is being joined. This is of particular value in brazing previously hardened and tempered parts without affecting the heat treatment. On the other hand, induction heating is sufficiently flexible to permit simultaneous brazing and hardening in certain applications.

Induction brazing and soldering is ideally suited to high production runs, but is also well adapted to intermittent or short time runs because the equipment can be placed in operation quickly, and there is no furnace or special atmosphere to control and maintain during idle time.

This method of brazing also permits the use of considerably fewer and less complicated fixtures for processing parts, and affords much greater flexibility than other methods of heat treating, since the same equipment can be used for different jobs with only a change in the heating coil.

In emphasizing the savings possible with high frequency induction heating in a wide variety of soldering and brazing applications, uniformity and improved quality of product should not be overlooked. In most cases, higher quality and lower production costs go hand in hand. Even where savings cannot be conclusively demonstrated, however,

An extremely simple fixture used to braze six different parts.

Prepared by INDUCTION & DIELECTRIC HEATING APPARATUS SECTION, NATIONAL ELECTRICAL MANUFACTURERS ASSN.

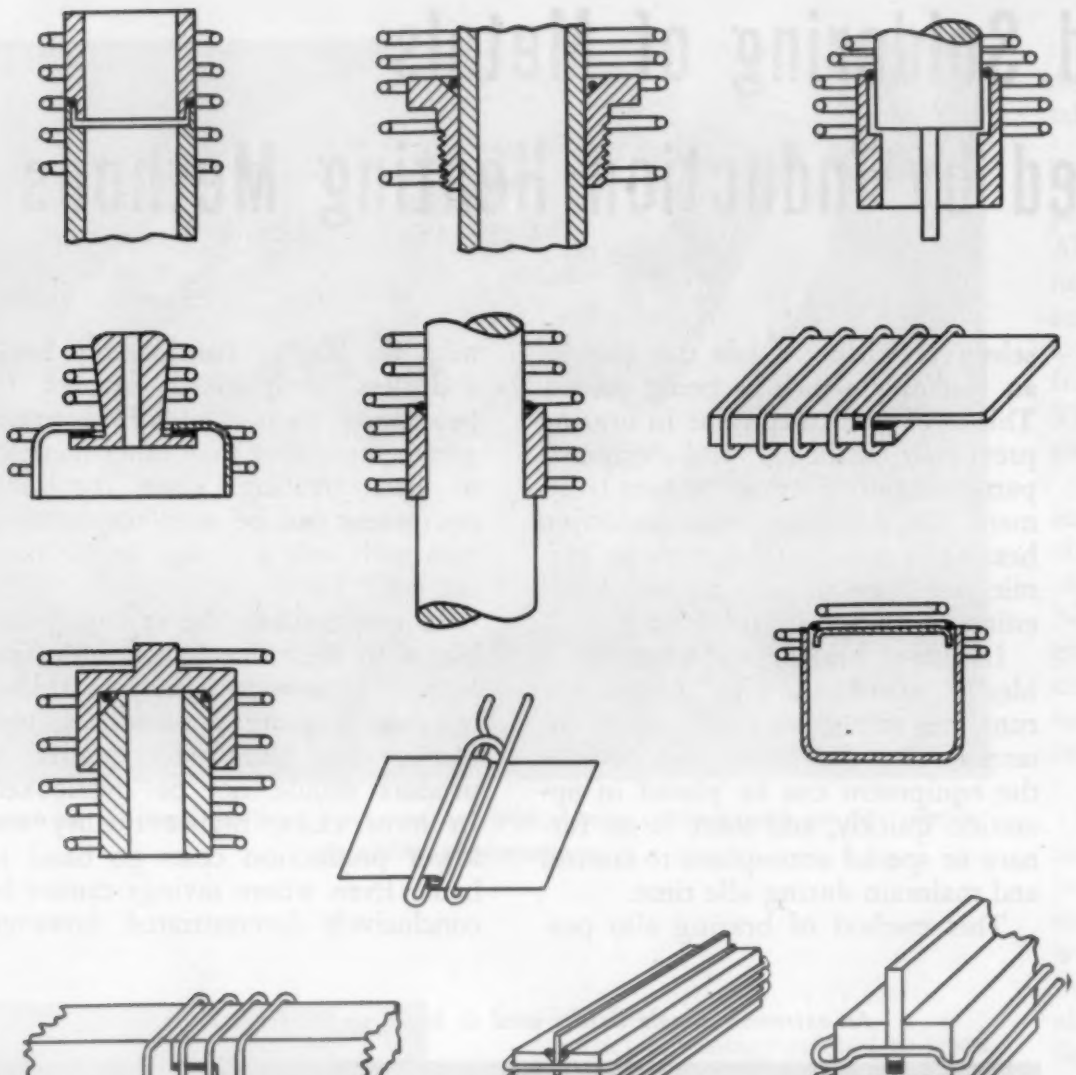
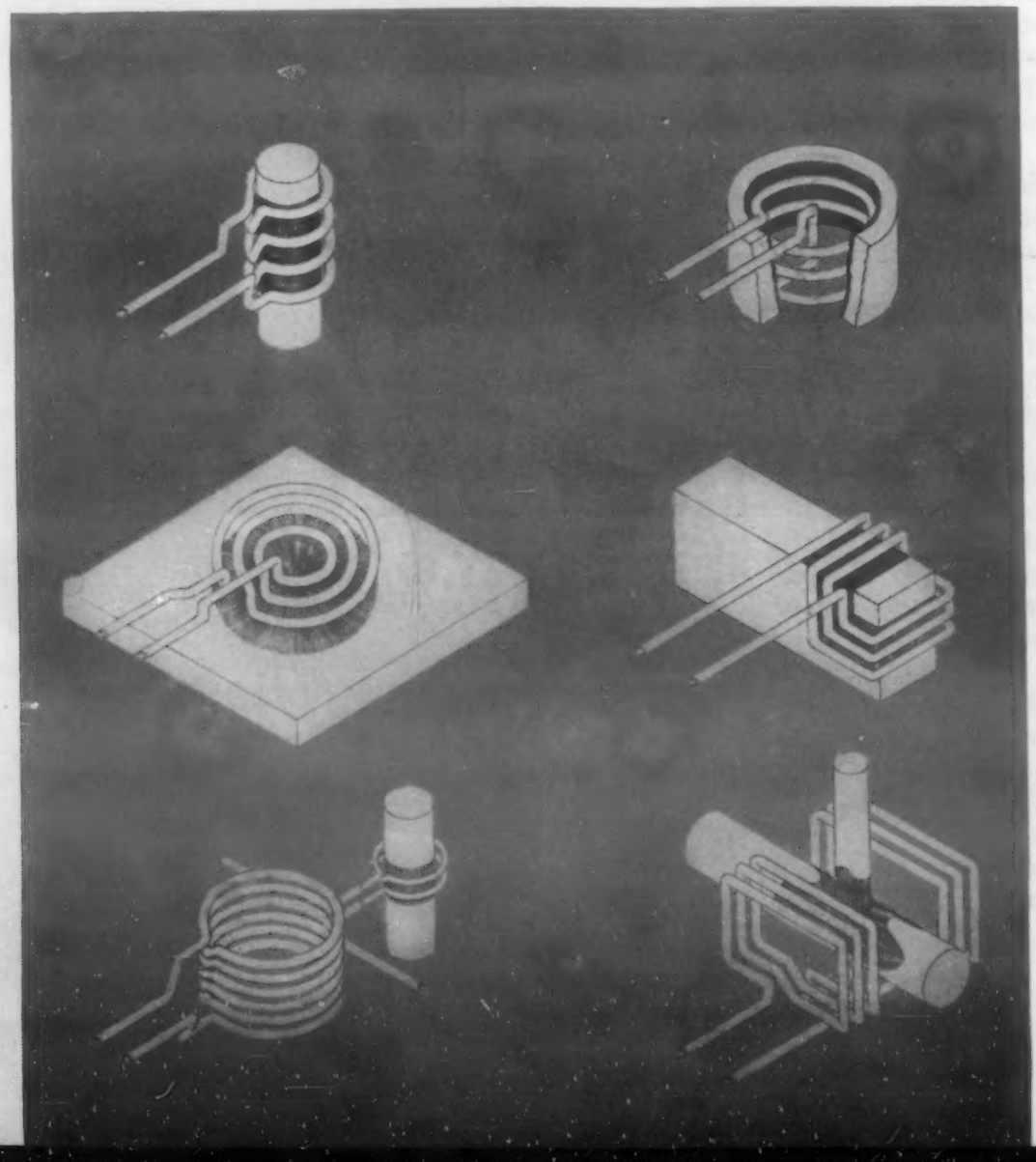


Fig. 1—Typical joints that are soldered or brazed by induction heating.

Fig. 2—Typical heat patterns obtained with various coil shapes.



quality considerations warrant a careful investigation of high frequency heating.

Design Considerations

In order to produce satisfactory joints by high frequency induction brazing or soldering, a few simple rules must be followed. Of particular importance is the preparation of parts prior to heating. Well-fitted parts are necessary to obtain uniform heating and even distribution of the brazing or soldering alloy, and surfaces must be thoroughly clean.

Also important is the proper selection of a heating coil and its placement with respect to the joint. Allowance must be made for the fact that the parts of an assembly expand while being heated. If, for example, an assembly of two telescoped sleeves is to be soldered or brazed, improper placement of the coil may expand the outer sleeve to such an extent that heat transfer to the inner sleeve is reduced, with the result that the former becomes overheated before the latter reaches its proper temperature.

Wherever possible, the heating coil should be designed and placed to heat all members of an assembly uniformly in order to obtain an even flow of solder in the shortest possible time. Fig. 1 shows some typical arrangements, while Fig. 2 illustrates some characteristic heat patterns. Also indicated in these illustrations is the placement of the brazing alloy or solder. The design of the joint will determine the best location for efficient solder distribution and economy. As the same quantity of solder is used for each similar joint in a repetitive operation, joints identical in appearance and strength will result.

Induction heating is particularly well adapted to mechanized handling of the work, since pre-assembled

Table 1—Tin-Lead Soft Solders

Alloy	Composition, %		Melting Point, F
	Tin	Lead	
10/90	10	90	574
20/80	20	80	555
25/75	25	75	510
30/70	30	70	495
35/65	35	65	472
40/60	40	60	460
50/50	50	50	415
60/40	60	40	370
63/37	63	37	358
70/30	70	30	367
80/20	80	20	386
90/10	90	10	416

parts can be prepared ahead of time and placed upon a conveyor belt or other carrier to be fed through a high frequency coil for quick, uniform processing. Some means will generally be required for holding or aligning the parts of an assembly in their proper relation. Fixtures of relatively simple design will normally be adequate for this purpose, and need not be of heavy construction. For most applications, fixtures built of Transite function very satisfactorily, and do not constitute a major investment.

Soft Soldering

Soft soldering, as the term is used in this article, is the joining of metals with alloys of low melting points (below 600 F). Soft solder consists mainly of tin and lead, the melting point depending upon the relative percentage of those metals in the alloy. Table 1 lists the common types of the tin-lead solders.

Soft solder is generally used on radio condensers, blow torches, jewelry, sprinkling cans, air rifles, terminal strips, condenser transformer cans, radiators, etc. The metals joined with soft solder are brass, copper, bronze or tinned sheet steel. These applications lend themselves readily to high frequency induction heating because of the low power input required to attain the relatively low temperatures involved.

Tin-lead solder is available in the following forms: (1) Sheets or ribbon in various thicknesses and widths; (2) rods and wire in different diameters; and (3) powder of various meshes. The powder form of alloy can be obtained as a paste, mixed with acid or rosin flux, while the wire form is available with either a rosin or acid core.

Soldering powders are used primarily on delicate and small pieces of work, such as encountered in the jewelry trade, where it is impractical to pre-place a solid piece of solder.

Fluxing materials are used to remove slight oxidation, or to prevent it during heating. These fluxing agents are available in a wide variety, generally known only by their trade names to safe-guard either patented or unpatented formulas. Basically, fluxes are classified as:

Mild fluxes—commonly known as *rosin fluxes*—
Tallow, stearin, rosin, rosin-alcohol or rosin-turpentine.

Strong, or acid fluxes—
Zinc chloride, with or without ammonium chloride.
Zinc chloride made by dissolving zinc in hydrochloric acid.
Paste flux made with petroleum jelly, zinc chloride and a small amount of water.

It should be borne in mind that all acid fluxes are corrosive; if this is objectionable for a particular application, one of the rosin fluxes should be used.

Aluminum Soldering and Brazing

Aluminum solder and brazing alloys are available in different forms and shapes, but are most commonly used in the wire or rod shape. They have melting points which vary from around 950 to 1075 F. The melting point of the base metal, which is invariably aluminum, is 1100 F. Because of the small temperature differentials between these joining alloys and base metal, the use of high frequency induction heating is very much restricted, especially since with most applications the base metal is thin (1/16 to 3/32 in.). With heavier parts, the process becomes less critical and is better adapted to induction heating.

Requirements for aluminum soldering or brazing by means of high frequency generators are: control of power input to enable both parts of an assembly to come uniformly to the same temperature; and proper load coil design to permit uniform heating of both members of the assembly.

The size of the generator depends largely upon the mass of the part to be joined. Power input to the work is usually low. The coupling between work and coil is made rather loose to obtain gradual but uniform heating of both members of the assembly. This emphasis on uniform heating results in a prolonged heating cycle, and makes high frequency induction heating only in a few cases competitive with torch heating for aluminum soldering and brazing applications.

Some special aluminum solder alloys—known under various trade names, *i.e.,* Alumaweld or Lloyds Solder—have melting points considerably less than the standard alloys, varying from about 450 to 750 F. This type of solder does not flow when applied to an assembly, but must be rubbed on to adhere to the surface. While certain applications might be satisfied with this solder, tests show that corrosion resistance and tensile strength are low, which limits its usefulness.

Brazing

Brazing or hard soldering is an important application of high frequency induction heating. The process is like soft soldering, except that a brazing alloy and a higher temperature are used to produce a strong joint.

Table 2—Silver Brazing Alloys

Name	Composition, %				Melting Point, F	Flow Point, F
	Silver	Copper	Zinc	Others		
Easy-Flo	50	15½	16½	18 Cd	1160	1175
Easy-Flo 3	50	15½	15½	16 Cd 3 Ni	1195	1270
Easy-Flo 45	45	15	16	24 Cd	1125	1145
Easy-Flo 35	35	26	21	18 Cd	1125	1295
Sil-Fos	15	80	—	5 P	1185	1300
TE Special	5	58	37	1575	1600	—
SN 7	7	85	—	8 Sn	1735	1805
TL	9	53	38	—	1450	1565
AT Special	20	45	35	—	1430	1500
ATT	20	45	30	5 Cd	1140	1500
NT	30	38	32	—	1370	1410
SS	40	30	28	2 Ni	1240	1435
DT	40	36	24	—	1330	1445
DE	45	30	25	—	1250	1370
ETX	50	34	16	—	1275	1425
RT	60	25	15	—	1260	1325
RT-SN	60	30	—	10 Sn	1095	1325
RE-Mn6	65	28	—	5 Mn 2 Ni	1385	1445
Easy	65	20	15	—	1280	1325
Medium	70	20	10	—	1335	1390
BT	72	28	—	—	1435	1435
Hard	75	22	3	—	1365	1450
Hard 1	75	20	5	—	1350	1425
TR 1	75	—	25	—	1300	1345
IT	80	16	4	—	1360	1490

The most commonly used brazing materials are silver (pure or alloyed), brass, copper and bronze. These metals have different melting points and produce joints of varying tensile strength. The selection of the best brazing alloy depends upon many different factors. As the alloy must melt at a temperature below the melting point of the metals to be joined, these alloys are grouped in three classifications:

Class I — Silver brazing alloys or silver solders having melting points ranging from 1200 to 1600 F.

Class II — Brass and nickel-silver brazing alloys having a melting point from 1600 to 1700 F.

Class III — Copper and copper alloys having a melting point from 1600 to 2250 F.

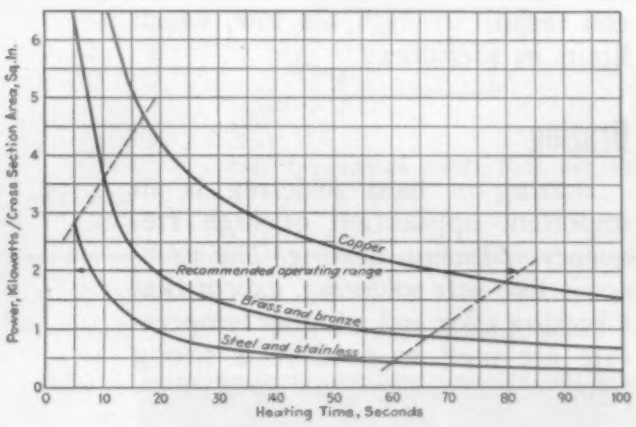


Fig. 3—R.F. generator rating required for soft soldering at a temperature of 370 F.

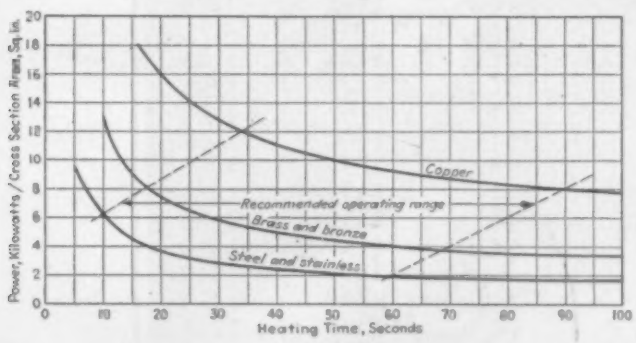


Fig. 4—R.F. generator rating required for silver soldering at a temperature of 1300 F.

In general, the use of silver alloys should be considered where the higher temperatures required for other brazing alloys might cause excessive grain growth or damage to the materials to be joined, and where strong ductile joints are necessary. Silver alloys can be obtained in all sizes of wire and gages of sheet, and also in filling or powder form.

Table 2 covers silver alloys commercially available. Additional listings of such alloys will be found in the 1948 edition of the "Metals Handbook," or can be obtained from the different suppliers.

Among the Class III brazing alloys, the most commonly used is phosphor copper. This alloy has a melting point of 1304 to 1526 F. Pure copper, with a melting point of 1980 F, is used for copper brazing. Due to this high temperature, a neutral atmosphere such as hydrogen or illuminating gas is essential to prevent oxidation of the parts.

Fluxes used for brazing with almost all alloys are generally the same, and can be quite simple in preparation. For example, ordinary borax, either dry or mixed with water, forms a very good flux. Most commonly used, however, are commercial preparations available in paste form. No flux is used with phos-copper or Sil Fos, since the phosphor in the material acts as a flux. These alloys cannot be used for brazing steel parts because the phosphor in the alloy embrittles the steel.

Heating Cycles

In estimating the required heating cycle when applying high frequency power to soft or silver soldering applications, the charts shown in Figs. 3 and 4 will be helpful. They are based on theoretical calculations of heat flow in metals, and include coil losses, coupling efficiencies, and radiation and conversion losses typical of such applications. These calculated results have been checked with actual soldering applications, and have been found to be in fair agreement.

To use the charts, estimate the permissible heating time in seconds per piece, based on the desired production rate. Allow sufficient handling time for loading and unloading operations as well as time for replacing solder rings and fluxes. Read off the answer in kilowatts per square inch, using the curve of the metal involved. Multiply this power density by the area in square inches of metal (perpendicular to the flow of heat away from the joint) on each side of the joint to be soldered. The sum of power so obtained represents the necessary output power of the high frequency generator. If the power input to the high frequency generator is desired, multiply the output power by two, as the normal over-all efficiency of a high frequency generator is approximately 50%.

If several pieces are to be heated simultaneously in a gang or multiple position load coil, the total output power referred to above is the product of the number of pieces to be heated and the power per piece. As will be noted from these charts, brass, bronze and copper assemblies require a considerably higher power density than steel; with these metals, therefore, either the size of the high frequency generator or its conversion efficiency must be high in order to obtain economical results and reasonably short time cycles.

Practicability of Induction Brazing and Soldering

Whenever consideration is given to high frequency induction brazing or soldering, several points with regard to its economy and practicability should be carefully observed.

Depending upon the number of parts to be processed and the temperature required, induction brazing, in particular, must be considered first of all in the light of existing heat treating equipment in the plant. A given application might be economically successful in one plant and a complete economic failure in another due to these considerations.

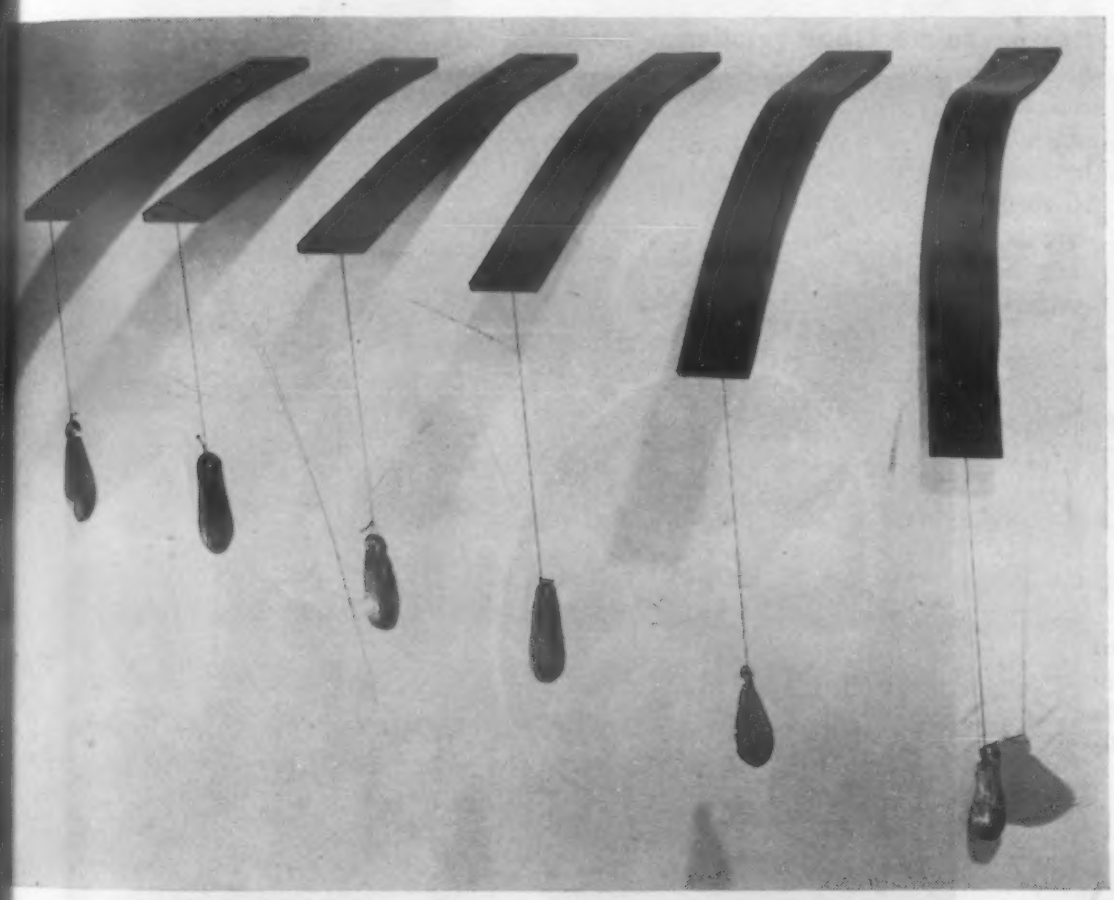
One should always be hesitant in using high frequency heating for copper brazing because of the high temperature involved and the poor appearance of the work after processing, even though a hydrogen atmosphere is employed. There are available a number of silver brazing alloys which have flow temperatures considerably below that of copper, yet produce comparable strength values in the joint. These alloys should be considered instead of copper when designing for high frequency heating.

Whether or not an assembly can be effectively brazed or soldered with an existing high frequency generator or converter can be determined from prepared charts furnished by the manufacturer. In most cases, however, the user of a high frequency heating installation knows from the past performance of his unit what to expect before investing money in elaborate load coils and fixtures. If in doubt, consultation with the manufacturer of the equipment is advisable.

Durable Industrial Parts Molded from Thermosetting Plastic-Rubber Blend

High resistance to abrasion and chemical attack make this new material a likely competitor of hard rubber.

by KENNETH ROSE, Western Editor, Materials & Methods



Strip at left is hard rubber; at right is soft rubber. Four strips in between are Enrup, illustrating the varying degrees of flexibility obtainable in this material.

Table 1—Typical Physical and Mechanical Properties of Enrup

	EN-56	EN-80	EN-95	EN-58
Specific Gravity	1.28	1.35	1.34	1.32
Tensile Strength, Psi.:				
As Molded	2030	2600	3500	4400
After 1 Week at 212 F	2730	3000	4100	5240
Hardness:				
Rockwell M	—	65	—	—
Durometer "D"	65	70	75	80
Izod Impact Strength, Ft.Lb./In. Notch	2.10	1.30	0.90	0.48
Young's Modulus of Elasticity, Psi.	45,700	99,000	166,000	236,000

● A THERMOSETTING plastic-rubber blend expected to replace hard rubber in many industrial applications has been developed by U. S. Rubber Co. The high-strength, lightweight material, called Enrup, is also expected to compete with nylon and the phenolics for certain applications.

Composition of the new material has not yet been made public but its combination of properties indicates that it is probably a phenolic thermosetting plastic blended with Buna N synthetic rubber.

Resistant to abrasion and chemical attack, Enrup can be produced in varying degrees of flexibility ranging between elastic soft rubber at one extreme and brittle hard rubber at the other. Although specific properties can thus be varied widely by adjusting the formulation, there are four standard grades available at the present time. As shown in Table 1, the room temperature tensile strength of these compounds ranges from 2000 to 4400 psi., Durometer "D" hardness from 65 to 80, and modulus of elasticity from 45,000 to 236,000 psi. Impact strength is believed to be better than that of most plastics now on the market.

In service, the new material has demonstrated good resistance to the deteriorating effects of oils, solvents, acids and mild alkalis. Although it has a heat distortion temperature of 190 F, this material actually retains practical dimensional stability up to 250 F and sometimes higher, depending upon the particular application. Its high dielectric strength makes it a good electrical insulator. Chemical and electrical properties are listed in Table 2.

Enrup is available in the form of sheet, rods, tubes, gear blanks, and as molded parts. It can be produced on standard rubber processing equipment, the available manufacturing methods including rubber press molding, compression molding, transfer molding, sheet molding and fabrication from sheets.

One of the principal uses of the plastic-rubber blend is in high-strength, low-cost gears to replace metal gears in such applications as heavy-duty lathes, household appliances, plating barrels, automotive timing devices and dynamometers. These gears are molded in one piece to close tolerances, eliminating the need for elaborate finishing operations. Such gears have been operating for more than a year in applications where conventional metal gears have failed within a few weeks.

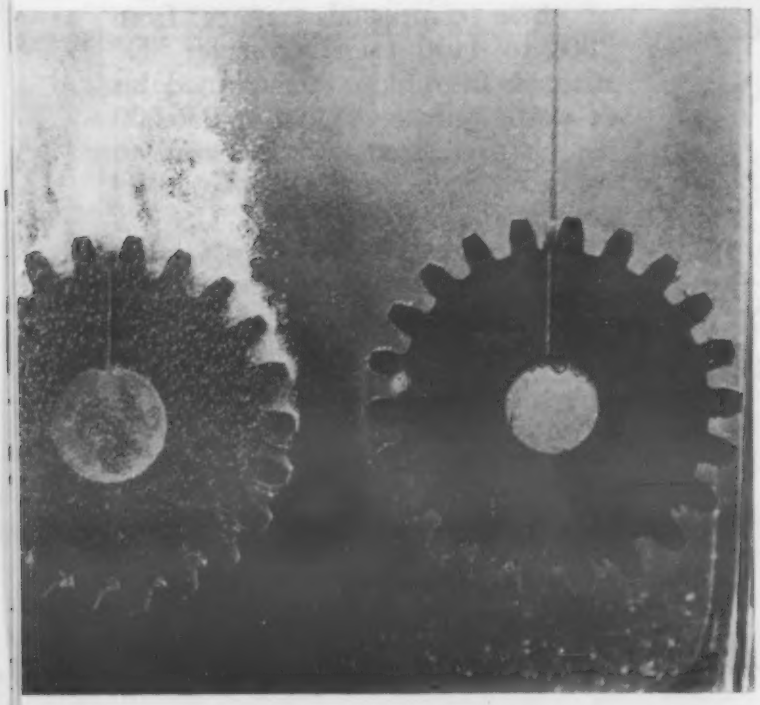
A specific application where the durable material appears particularly suitable is in washing machine parts. Its resistance to the new types of synthetic detergents gives it an important advantage over metal.

Among other potential applications for the plastic-rubber material are: fuel pump parts, battery cases, dies and jigs, valve seats, buckets for carrying chemicals, plating barrels, filter press plates, photostat separator plates, tote boxes, bearings, electrical insulators, and various automotive parts such as cam shaft timing gears, water pump impellers, ignition coil housings, distributor caps, low-load and low-speed bearings, and bushings.

Table 2—Chemical and Electrical Properties of Enrup

Water Absorption, % in 24 Hr.	0.3
Resistance to Chemicals:	
Cold Acid	Excellent
Hot Acid (Except Oxidizing)	Good
Cold Alkali	Good
Hot Alkali	Fair
Solvents	Excellent
Gasoline	Good
Fire Resistance	Fair to good
Heat Distortion Temperature	190 F
Safe Operating Temperature	0 to 250 F
Electrical Properties:	
Dielectric Str., Volts/Mil.	500
Dielectric Constant	9
Power Factor	0.20
Arc Resistance	Fair to good

Enrup has replaced hard rubber in the filter press plate, chemical bucket and photostat separator plate. The lap roll (lower left) used in the textile industry was formerly made of laminated phenolic at twice the present cost.



Chemical resistance of Enrup is demonstrated in this picture, which shows steel gear (left) and gear molded from Enrup (right) suspended in a 20% sulfuric acid solution.

Enrup drive gear has been operating in this 36-in. heavy-duty lathe for more than six months without visible signs of wear. (All photos courtesy U. S. Rubber Co.)

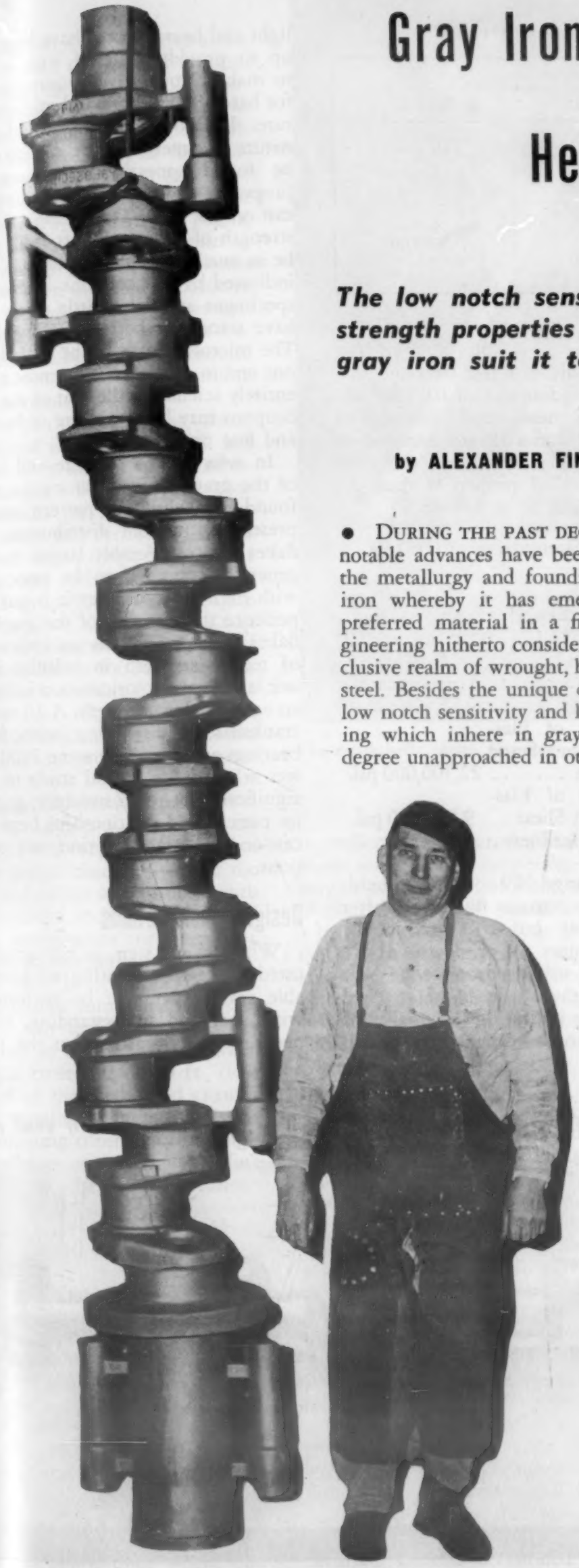
Gray Iron Preferred for Large, Heavy Duty Crankshafts

The low notch sensitivity, high damping and improved strength properties of properly processed and inoculated gray iron suit it to critical diesel engine components.

by ALEXANDER FINLAYSON, Chief Metallurgist, Pacific Car & Foundry Co.

• DURING THE PAST DECADE some notable advances have been made in the metallurgy and founding of cast iron whereby it has emerged as a preferred material in a field of engineering hitherto considered the exclusive realm of wrought, heat treated steel. Besides the unique qualities of low notch sensitivity and high damping which inhere in gray iron to a degree unapproached in other ferrous metals, the augmented tensile, endurance and elastic properties attainable through improved metallurgical technology have recommended it to machine designers for some of the most critical components of prime movers. An example of such is the diesel engine crankshaft.

It is, of course, recognized that cast crankshafts, as well as camshafts, have been employed in truck and automobile engines for many years and that millions of such castings so applied have manifested the sufficiency of both the material and the method. But the crankshafts here to be considered are a great deal bigger than the motor car variety in all respects, ranging in rough weight from 500 to 5000 lb. and in overall length from 6 to 18 ft. These units are designed with hollow throws and journals for engines having 5 to 12 cylinders and energy ratings up to 2400 hp. The solid portions vary in thickness with other sections between 1.5 and 7.0 in. in individual castings, thus presenting a series of manufacturing perplexities not encountered, or at least quite different from that involving the production of the smaller automotive types.



A crankshaft for a nine-cylinder diesel engine, cast from electric furnace processed iron. Overall length is 135½ in. and rough weight before machining is 2441 lb. Note test bars attached at various points to be removed for mechanical tests after thermal treatment.

Types of Gray Iron Used

Any of several proven analyses will suffice to develop high tensile strength and good machinability when the metal is properly processed and suitably inoculated. A choice from among these will thus be influenced largely by its ease of control, its stability in the molten state, its shrinkage characteristics and its economies. Examples of three generic types which we have used

Types of Gray Iron Used in Crankshafts

	% Composition		
	Type A	Type B	Type C
Total Carbon	2.20-3.00	2.20-3.00	2.25-2.75
Manganese	1.00-1.50	1.00-1.75	0.85-1.25
Phosphorus	0.05 max.	0.05 max.	0.05 max.
Sulfur	0.05 max.	0.05 max.	0.05 max.
Silicon	1.50-2.50	1.60-2.60	2.10-2.65
Molybdenum	0.85-1.10	0.80-1.20	0.65-1.10
Chromium	—	—	0.20-0.60
Nickel	1.00-1.50	1.75-2.50	0.65-1.50
Copper	1.00-1.50	—	—

successfully are given in the accompanying table.

Precise compositions, of course, are determined by the critical section thickness, the total mass, and the cooling rate of the castings to be poured. Type C, containing chromium, is somewhat difficult to control and has a strong tendency to develop objectionable carbides in lighter sections. Type A, on the other hand, is apt to form the weaker pearlitic structure with free ferrite and coarse graphite in heavy sections. Type B is most generally employed in our practice, and for the larger crankshafts (1000 lb. and over), is restricted to the following average:

Total Carbon	2.65%
Manganese	1.40%
Phosphorus	0.03%
Sulfur	0.03%
Silicon	1.95%
Molybdenum	1.00%
Nickel	2.10%

Engineering Properties

In the green condition, standard ASTM tension specimens cut from the integrally cast test bars and machined to a diameter of 0.80 in. will manifest a mean tensile strength of 62,000 psi. and a Brinell hardness of 275. After heat treatment, the average mechanical properties thus determined will be as follows:

Tensile Strength	70,000 psi.
Transverse Strength (2.0-In. Round Bar on 24-In. Supports)	15,500 lb. 0.40 in. (deflection)
Endurance Limit	35,500 psi.
Modulus of Elasticity in Static Tension	22,300,000 psi.
Modulus of Elasticity in Shear	9,800,000 psi.
Brinell Hardness	275

In the range 269 to 285 the hardness usually remains unchanged after heat treating but will occasionally vary 10 points up or down. Above 300 it will usually decrease.

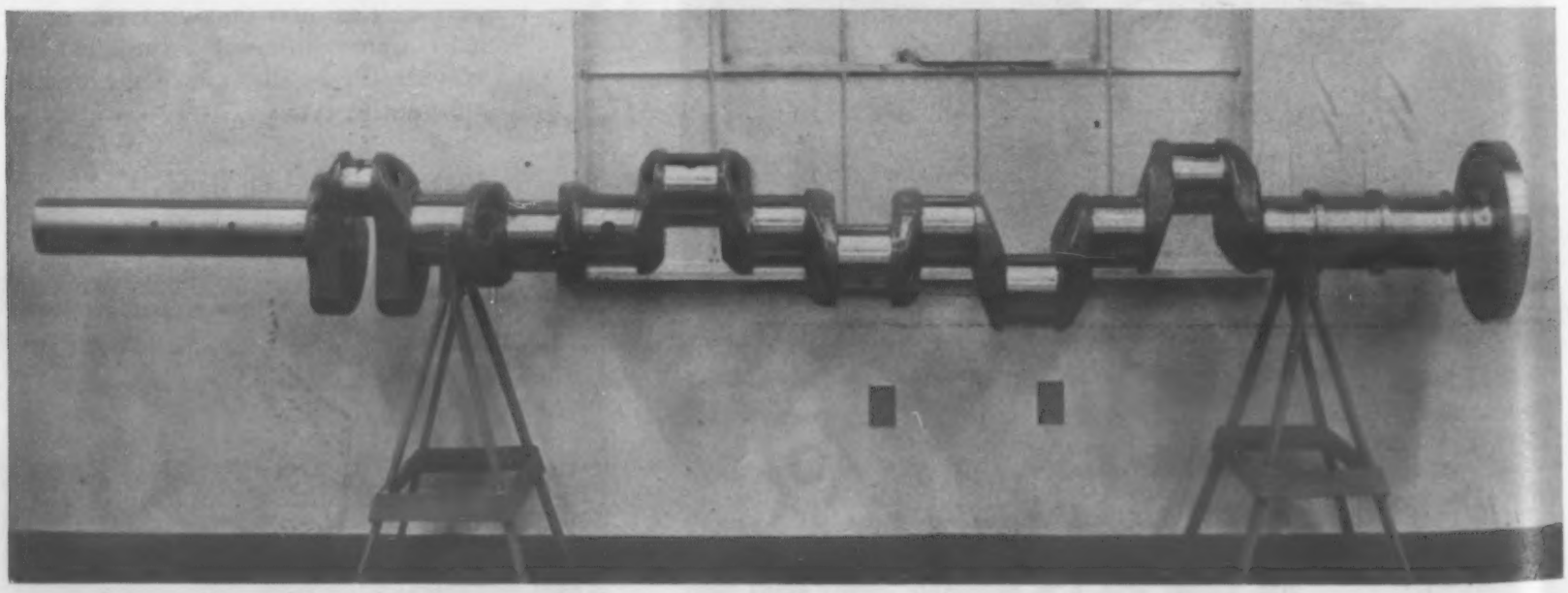
To test the adequacy of attached coupons for indicating the quality of the metal in the casting itself, both light and heavy cranks have been cut up to provide material with which to make comparative determinations for hardness, strength and microstructure. In most experiments of this nature the metal in the casting will be found superior in engineering properties and structure to that of the cast-on test bars. The average tensile strength of the crankshaft itself may be as much as 10% greater than that indicated by test coupons. The crank specimens are also a little softer and have somewhat better machinability. The microstructure of the shaft from one end to the other is, in most cases, entirely acicular while that of the test coupons may be a mixture of bainite and fine pearlite.

In reference to the size and form of the graphite in these cranks, it is found that while the pattern usually presents a random distribution, the flakes are considerably larger than is generally conceded to be associated with high strength. Yet it is our experience that the size of the graphite flakes is not necessarily an indication of tensile strength in acicular iron nor is a dendritic orientation in itself an agent of low strength. A 10-throw crankshaft, 13 ft. long with 8-in. bearings and weighing some 2800 lb., was selected for critical study in the significance of microstructure, graphite pattern and relationships between cast-on and crank section test coupons.

Design Considerations

While every step in the complicated process of creating an acceptable crankshaft must be performed with skill and understanding, none needs more attention than the pat-

A gray iron crankshaft for a five-cylinder diesel engine. The crank is fully machined except for holes in flange at fly wheel end.



rn. If the design incorporates a fair mpliance with the rules of symmey, applying the laws of solid conction and heat dissipation to insure e proper feeding and uniform cooling of all sections, many of the comon troubles arising from hot tears, ternal cavities and irregular tensile roperties are avoided in the beginng and thus need no correction at later period. In general, large cranks hich have been designed as hammer orgings cannot be cast advantageusly because of disproportions beween webs and bearings, and require onsiderable modification to promote ection uniformity.

With a casting, of course, metal n be placed where it is useful; left ut where it is known to be redunant. The pattern provides a conenient means for nice adjustments this respect and permits unlimited finements in the shape and contour f unmachined surfaces.

Cranks up to 90 in. in length are achine molded, and the pattern in uch cases is bolted to a stoutly ribbed eel platen. Molds for longer cranks re produced on the floor with a tationary sand slinger, the pattern ere being mounted on a wooden oard built up with heavy double tringers.

Shrinkage allowance for crankshaft atterns is largely a matter of experience. It will vary in the first place with the design characteristics of the asting, and in the second place with he composition, melting practice and pouring temperature of the iron. With the shorter units, small variations in these latter factors are not ignificant since minor discrepancies n length can usually be offset by djustments in machining. But when he length exceeds 9 or 10 ft., close egulation of the established chemistry and metallurgy is indispensable for maintaining consistency in longitudinal dimensions. Comprehending ll conditions, the shrinkage allowance for high strength cast iron rankshafts such as we produce will ange from 1/10th to 1/16th of an n. per ft.

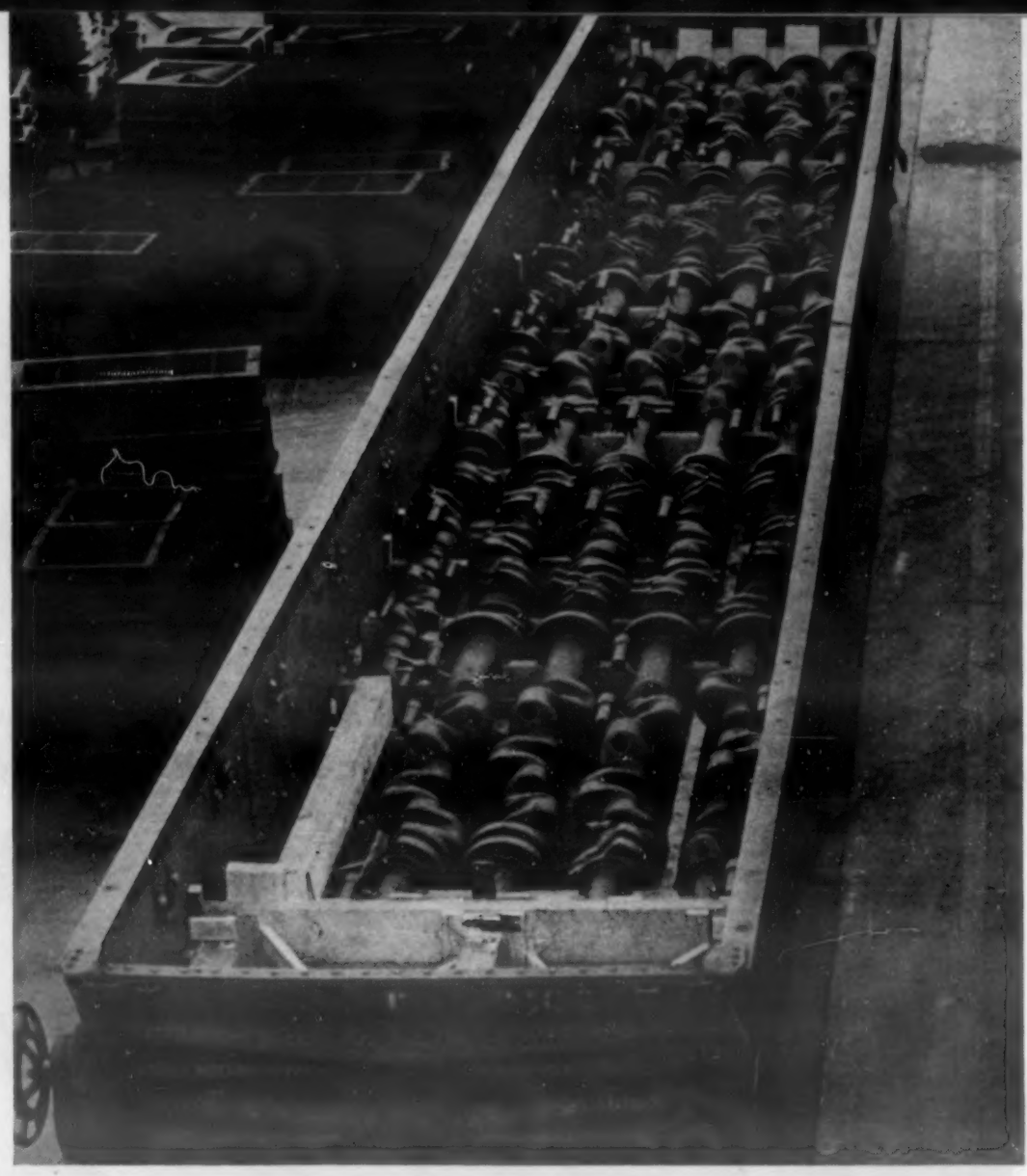
Cast Iron and Steel Compared

Steel and iron cannot properly be compared solely on the basis of the engineering characteristics of steel any more than they may be compared solely on the basis of the engineering characteristics of iron. Steel exhibits some valuable properties which iron does not possess but which are nevertheless of no value whatever in applications where iron is indicated. Conversely, iron possesses some unique properties which may be completely lost when applied in places where steel would manifest a better engineering balance. For example, the static tensile properties, and especially the ductile properties of steel, fall far into the background in importance in comparison with anti-friction and crackless plasticity when we are thinking about crankshafts.

A bar of soft ductile steel may be caused to fail with a brittle fracture if the stress is concentrated in a notch, but because of the random distribution of graphite in properly-made high tensile iron, a sudden stress cannot travel along a single plane or in a straight line but will be diffused and distributed in many directions, and unless very severe, will not induce cracks at a localized point which will progress to failure.

In addition to the well known mechanical and physical attributes of cast iron, the fact that it is cast to predetermined shape must not be overlooked. By this recourse the differences in strength occasioned by grain orientation or directional fiber, as in forged or rolled products, is not incurred. Defects occasioned by the junction of columnar crystals growing inward from abutting isothermal surfaces are not contingent with gray cast iron because solidification precedes from millions of minute graphite particles throughout the mass forming crystals that are nondescript in orientation and equiaxed. Machining waste of both material and labor is substantially reduced, superfluous weight avoided and with hollow journals, throws and end extensions, cast cranks are commonly designed to substitute block forgings having twice the finished weight.

One of the great drawbacks to the development of new designs for crankshafts when employing wrought materials lies in the fact that the units must be formed by forging, cutting and related mechanical processes which impose severe limitations on section contour, weight distribution and the avoidance of useless mass. With a casting the only limitations respecting design are those concerned with section uniformity, but since the preferred designs, from the standpoint of stress distribution and functional intent, are usually the best adapted for production as a casting, there is rarely any serious problem in this regard.



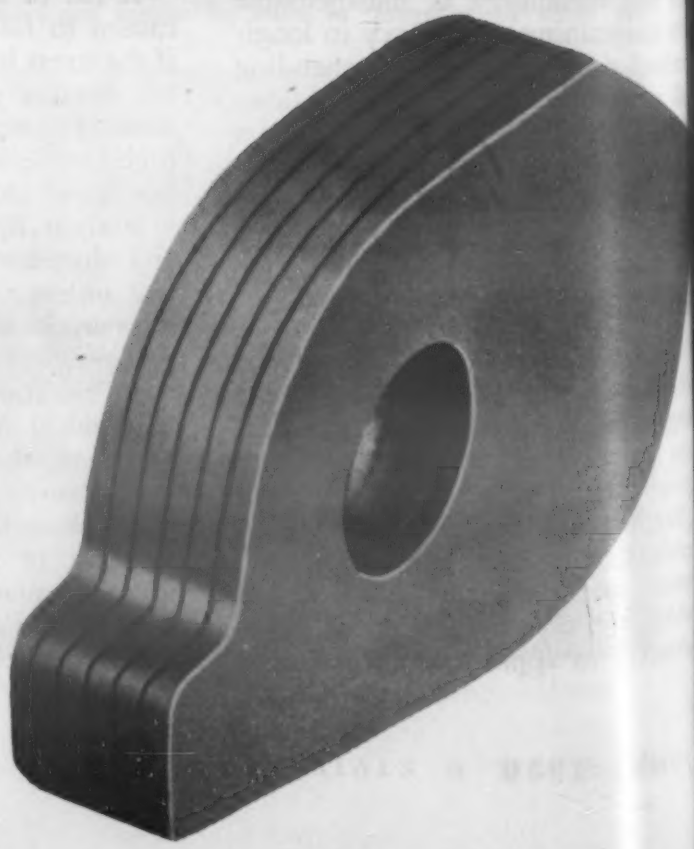
The crankshafts shown here vary from 86½ to 136 in. in overall length, and in throws from 5 to 10.

Materials at Work

Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .

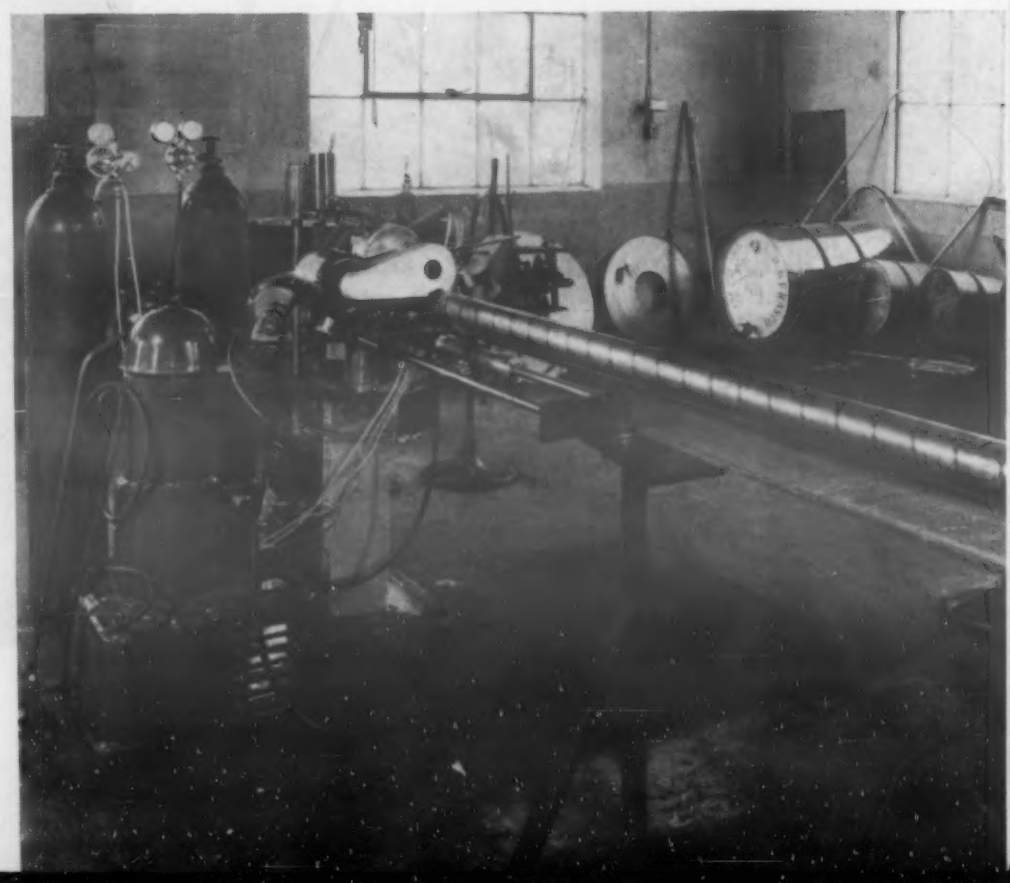
TRANSPARENT PLASTIC PLANT PROTECTORS *Claimed to outlast protective paper caps by several seasons, these clear Tenite plant protectors permit quick inspection of plants and seedlings without removal or replacement of caps. The Tenite caps, a product of Tennessee Eastman Corp., can be easily set out by covering the flanged bases with dirt, and are claimed to advance the maturing of young plants.*

COPPER BRAZED CAM *Designed primarily to reduce cam costs even on relatively small lots, this unit is composed of stamped steel laminations, stacked together, and copper brazed into a single unit by Technical Metal Processing Co. The resulting cam is approximately equal in strength to those made from solid steel. They have a high degree of accuracy and can be heat treated by conventional methods. Savings are substantial because costs are inherently low.*

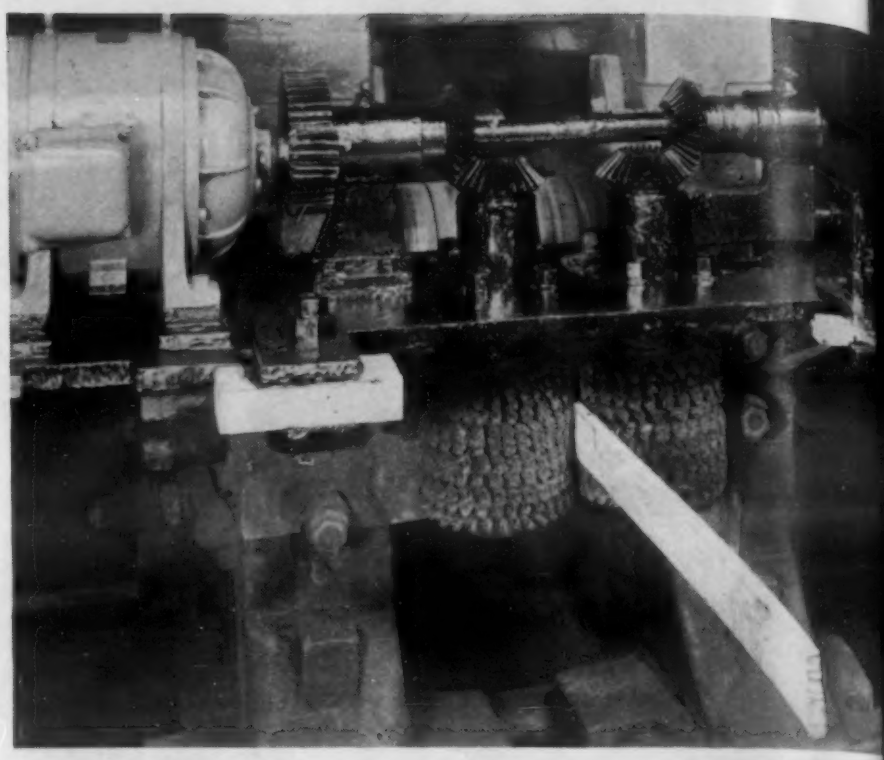


MAGNESIUM-ALLOY CHAIN SAW *Powered by a 3-hp., single-cylinder, 2-cycle, air-cooled gasoline engine, this portable chain saw weighs only 25 lb. complete with blade and chain. The unit is built almost entirely of high strength magnesium-alloy die castings by McCulloch Motors Corp., and is designed for cutting cordwood, land clearing, felling and bucking timber, tree surgery, and other uses.*

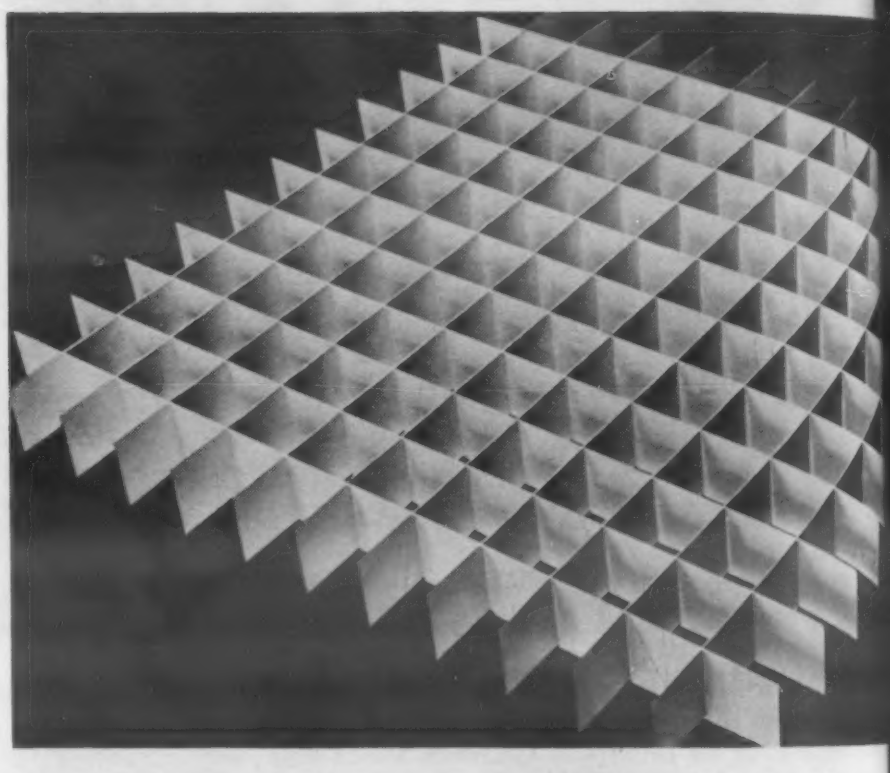
STAINLESS STEEL TUBING *A new technique for the mechanized inert-gas-shielded arc welding of stainless steel tubing has been developed by the B & M Manufacturing Co. The edges of the stainless strip are "squared" against Carboloy tools as the strip is fed to the coiling machine. The correct amount of pressure can be applied to the melted edges of the strip by finger-tip control of the angle of coiling. Exact strip widths are unnecessary for each outside diameter of tubing; thus, costs are reduced where short runs of numerous sizes must be made. Due to exact control of strip edges at point of welding, much thinner wall sections can be welded, particularly in the larger diameter tubes. Since spiral coiling works the material to a lesser degree than conventional straight seam forming, spirally welded stainless tubing can be cold worked to a greater extent without an annealing operation. No straightening operations are required before further bending or cold drawing, and the dimensional accuracy of the tubing is exceptionally good.*



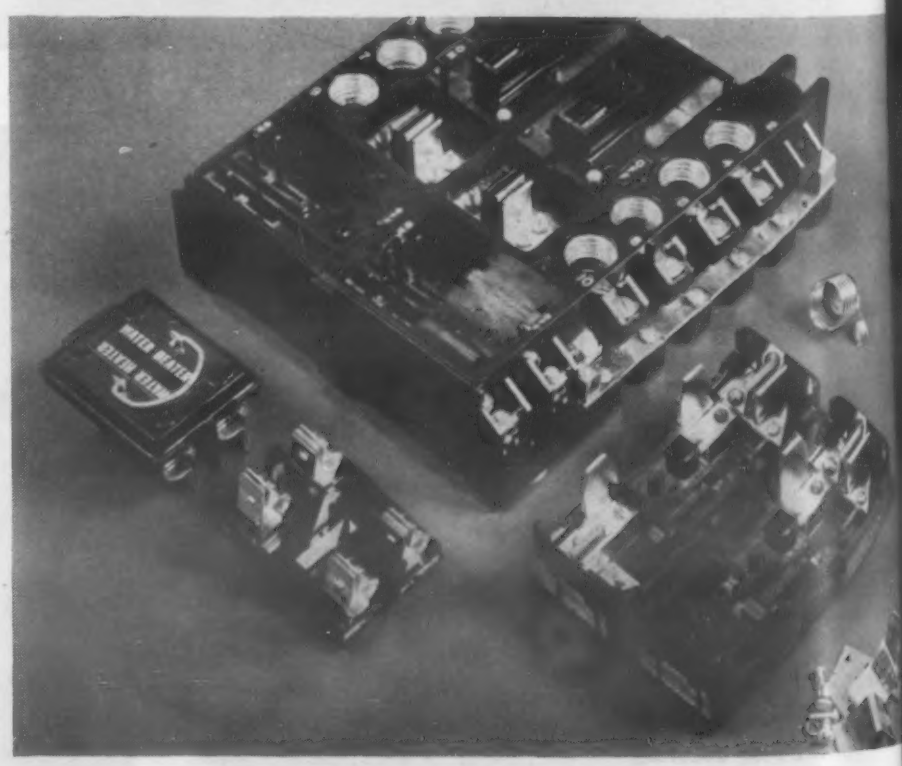
Materials at Work



STEEL WIRE BRUSHES *Heavy brushes, constructed of knots of 0.016-in. steel wire individually secured in a one-piece steel center, have been developed by the Osborn Manufacturing Co. for the removal of secondary mill scale from flat steel shapes in hot mill operations. The brushes are driven by a 2-hp. motor running at 1400 rpm. with 3:1 gear reduction, and operate in a water spray for cooling purposes. As the wire bristles wear down, one of the shafts is moved closer to the other to compensate for the wear. Brush descaling removes about one-half of one percent of the weight of the steel stock.*



ALUMINUM GRID *Designed for new construction or remodeling applications, this aluminum louvered ceiling grid offers decided advantages from illumination, installation and maintenance standpoints. The aluminum squares diffuse and reflect light downward to provide more uniform illumination, and the silvery, satin-like surface eliminates glare and facilitates cleaning. The lightweight grid sections, a product of the Kawneer Co., can be installed around overhead pipes, sprinkler and electrical systems without alteration of existing installations.*



PHENOLIC SWITCH BASE *Reportedly the largest molded phenolic plastic base ever used in a Main-and-Range pull switch, this unit has been produced by Federal Electric Products Co. of Durez plastic. The new switch has been designed to meet the demand for increased loads required in modern residential construction. The intricate mold design, comprising nearly 100 holes and slots, a dozen wall sections of varying thickness, and a number of bosses and recesses, are all molded in and require no extra machining operations when the piece comes from the mold.*

laterials & Methods Manual

s is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and application

60

Wire as an Engineering Material

by N. Bruce Bagger, Associate Editor, Materials & Methods

Wire is a versatile, basic metal form from which a variety of products can be made. Suitability for virtually all fabricating operations, and reduction in production time and costs which its use often makes possible, are several of the many advantages that the engineer and designer find attractive. This manual describes the basic characteristics of wire and the ways in which it can be worked and fabricated. It also gives the principal properties of the many different wire materials, and presents a number of typical applications to illustrate the versatility of wire as an engineering material.

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Introduction

Wire is a versatile metal form from which an almost unlimited variety of products can be made. It offers many advantages in the design and production of manufactured parts, and is recognized as a major basic form of material for modern industrial needs.

Wire is perhaps one of the oldest metal-working forms known; the use of wire as an engineering material dates back to 1700 B.C. when the Assyrians, Babylonians and Chaldeans used thin filaments of hammered bronze and gold in ornaments, tools, hooks, fasteners, and a score of other products in a primitive world. It was not until 800 or 900 A.D., however, that wire was first produced in round cross section by drawing through dies, principally to manufacture the chain mail armor used in the crusades against the Saracens and Turks.

From these slow beginnings, wire has assumed an increasingly important role as civilization has progressed. Today, authorities estimate that there are more than 1,000 applications listed in which wire, in one form or another, is customarily used. It takes only a glance at the things we live with, work with, and play with, to realize how all-encompassing this list actually is. And the listing continues to grow as the need for newer and better things arises and is fulfilled.

Characteristics of Wire

Materials

Virtually all the basic engineering metals can be satisfactorily drawn into wire. In addition, alloys achieving exceptional characteristics of heat and corrosion resistance, durability, and the like are customarily used for certain types of wire products. This total grouping includes the low, medium and high carbon steels; the alloy steels; the copper and copper-base alloys; the light metals and their alloys; and the so-called precious metals. As is often the case when metals and alloys are classified or grouped, some overlapping usually occurs, since a certain specific material may quite logically fall in more than one of the general, overall categories listed above. However, this grouping forms the general pattern into which wires are customarily arranged.

Some types of materials from which wires are commonly drawn have highly restrictive applications and are useful only under specified conditions. Others can be applied in much wider ranges, with cost, perhaps, being the sole limitation to their extended use. In all, however, the satisfactory selection of a wire for a specific application depends in a large measure upon a knowledge of the advantages and limitations of the material from which the wire is made, knowledge of the forming techniques to which the wire is subjected; and a knowledge of the service conditions to which the wire product will be exposed. It is from a thorough study of these factors that an intelligent and satisfactory selection of wire for a given application can be made.

The mechanical properties of any wire are determined by a number of related factors. Chief among these are the chemical composition of the metal itself, the reduction and amount of drawing, and the heat treatment, if any, given in the process or after final operation. Cold drawing has a more drastic effect in increasing the temper of wire than changing the alloying elements. By the same token, the softness and ductility can be increased by annealing. Thus, without regard to chemical composition, wire strength and hardness can be regulated by drawing and annealing operations and a wide range of temper from hard to extra soft can be achieved. By varying and correlating these factors, it is possible to obtain a wider range of mechanical properties and finishes on wire than is possible on any other metal form. This fact alone has probably been responsible more than any other, for the wide application of wire in its innumerable present-day uses.

Replacing screws, bolts, nuts, rivets, spot-welding, and cementing techniques, wire can be used effectively to fasten two or more entirely different kinds of materials together such as steel to rubber, fiber to asbestos, aluminum to steel or felt, steel to thick webbing, fabric to plastic, etc. Advantages of stitching are many. No holes are required to be drilled or punched. No tightening or setting time is required. Positive fastening is assured and space limitations are not important. Material costs are also low; a 5-lb. coil of carbon steel wire makes over 10,000 stitches. No. 18-290 gage wire (0.0475 in.) with a tensile strength of 290,000 psi. is commonly used for most stitching applications. For stitching soft or thin materials, lower tensile strength wire, such as No. 18-260 (260,000 psi.), is customarily used. (Courtesy Bostitch, Inc.)

Sizes

At this point, it might be well to clear up any confusion concerning rod and wire. Neither of these two metal forms is universally well-defined. Rods are popularly described as slender bars; wires are known as slender rods or threads. Rods are the product of rod rolling mills which are usually bar mills modified to roll to very small cross sections. These rods are coiled as they emerge from the finishing stand of rolls and are later drawn through one or more dies. The product of this drawing operation is wire, which is usually marketed in coils but may also be sold as straightened and cut wire. The difference between small sizes of cold-finished bars and large sizes of straightened and cut wire is a technical distinction involving points of tolerance, surface finish, and processing, and as such is beyond the scope of this paper. For practical purposes, wire will be considered as rod up to ¾-in. dia., since this is about the cross sectional limit that can be achieved without encountering difficulty in unwinding the coiled metal from a reel without breaking.

Tolerances

Although considerable efforts are made to draw wire as true to the required size

ize as possible, complete exactness is lly impossible under actual commer- onditions. Thus, all wire varies slightly her diameter or section. These varia- are the result of a varying degree of ess in the metal being drawn; a wear- of the die; or the type of coating, if on the drawn stock. Since some toler- is recognized as a necessary evil, it is important that it be kept to an irre- le minimum and that allowance be for it when utilizing wire as an en- ring material.

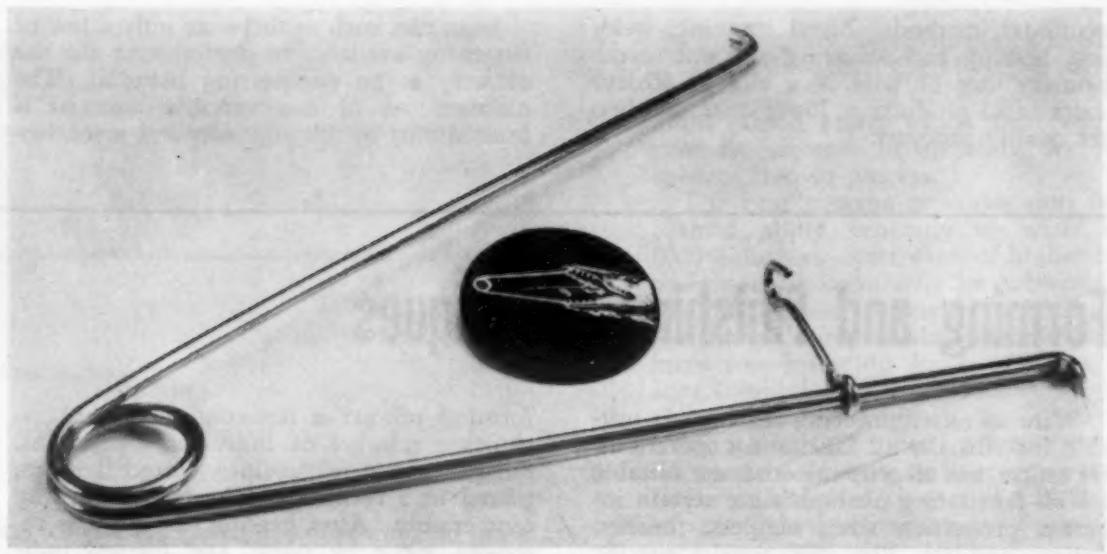
is common practice to work to three of allowable variations in diameter of wire. These allowable variations are able to different kinds or grades of and are designated as "regular," "spe- and "extra special" tolerances. Each of sets of tolerances contains the varia- allowable, and these are adjusted to ize of the wire in question. In the lar" tolerances, the allowable varia- range from 0.001 to 0.003 in.; in the ial" from 0.0005 to 0.002 in.; and in extra special" from 0.0005 to 0.001 in. ch case the larger allowance refers to e sizes and the smaller to the fine sizes. e intermediate sizes, variations between two figures are accepted.

ications

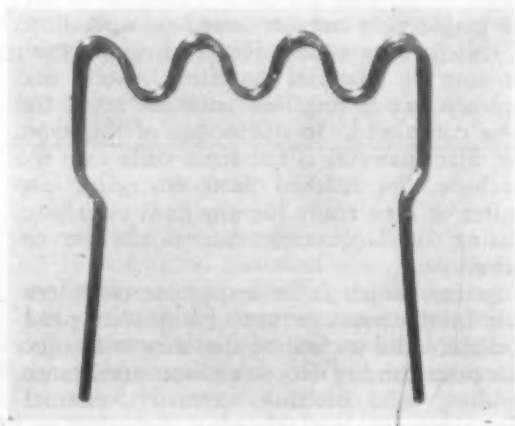
ire is customarily thought of as a d, string-like form of metal commonly for such everyday applications as pail screens, electrical conductors, and the But wire is not limited to these prosaic cations alone. Wire is also used as the form from which many manufactured cts are made. Many of these products been redesigned to take advantage of economies offered by the use of wire , alternate methods of manufacture, as casting, machining, stamping and ng, having been obsoleted in favor of either of circular cross section, or n to a specified shape.

ere are in use today literally hundreds rious-shaped wires, none of them even tely resembling wire in its commonly ght-of form. From these, a great variety oducts can be made. Typical of such cts are pinions, pivots and cams. Ini- , these are drawn as wire through one ore dies shaped to the cross-sectional n of the finished part. After drawing, ire is cut into proper lengths, thus ing the completed pinion, pivot or cam . This fabrication method, in reality e of extrusion, supplants the casting, ing or machining methods formerly and effects considerable production omies for such manufactured parts. An- instance, even more familiar, of where achieves remarkable production and rial economies, is the case of the ordi- coat hook. These hooks, formerly cast machined and requiring two or more ate wood screws for installation, are produced entirely from wire. One con- us piece of wire is bent to form the proper, an end of the wire projecting the configuration being rolled to pro- the wood screw threads by means of h the hook is secured to the mounting ce. This redesign has eliminated the rate mounting screws completely; has led production immeasurably; and has led a thoroughly practical article to be uced at a fraction of its former cost.

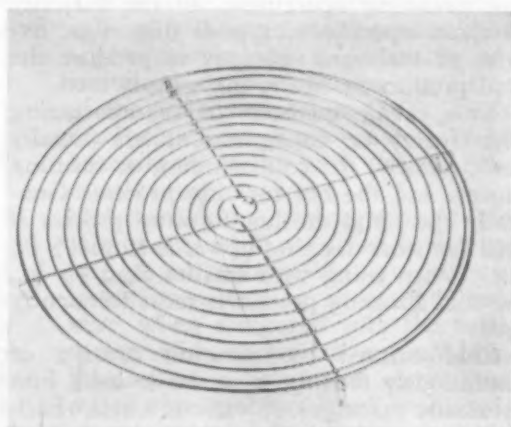
ire forms or configurations of this type usually made of round wire. These s may or may not have a spring appli-



Replacing a tempered stamping that was limited in both its effectiveness and its customer appeal, this fish-jaw-lock for the sportsman is now produced from Type 430 stainless steel wire to achieve a product that is lower in cost, more efficient, and lighter in weight than its cumbersome predecessor. (Courtesy Carpenter Steel Co.)



Supplanting conventional plating techniques, this filament, formed from 0.025-in. tungsten wire, is used for heating metals which are vaporized and deposited on metallic or nonmetallic parts in special vacuum equipment. It is used for depositing thin aluminum coatings on television tubes, and contributes to the low cost and high output that is essential in such mass-production industries as this. (Courtesy Fansteel Metallurgical Corp.)



Formerly made as a stamping from sheet stock with perforations drilled or punched to allow for passage of air, this cake cooler has been effectively redesigned to take advantage of the inherent characteristics of stainless steel in wire form. Made from Type 302 stainless, the resulting product is lighter in weight, more pleasing in appearance, easier to clean, and considerably more economical to produce than the conventional bulky and expensive product it supplants. (Courtesy Carpenter Steel Co.)

cation, in that they serve all purposes from paint-can handles to specially configured retainers and clamps. If the form is to serve as a spring, it is usually made of a regular spring wire tempered before or after forming, depending upon the difficulty with which the required formation might be made. If stresses are not excessive, hand drawn spring wire can be used, and when the wire form has no spring purpose to perform, it is made of virtually any drawn wire having physical properties germane to the application.

Wire forms, springs and otherwise, play an important part in the radio and television industry. Electronic tube parts—single helical, double helical, corrugated ribbon and other filaments, spring hooks, plain or pointed supports, anodes of varying design—all are produced from wire as a basic engineering commodity.

With so many common uses of wire around us, such as bolts, nails, screws, fins, springs, wool and nuts, there is a tendency to overlook some of the lesser-known uses of this versatile material. Special drills, for instance, are often made from drawn wire for drilling the jewels used in instrument and timepiece bearings. Such drills are from 0.0015 to 0.020 in. in dia. and are usually accurate to one ten-thousandth of an in. in dia.

Another odd use of wire, for which no adequate substitute has been found, is in the manufacture of artificial pearls. These imitation jewels are made of special glass beads which must have a hole through which they are strung. Glass is melted on a perfectly straight suitable wire and by close control of wire rotation and temperature, a sphere is generated. After the pearl is formed, the wire is dissolved by acid and the manufactured pearl finished with lacquer to approximate the genuine article.

The deposition of metal has been long recognized as an important and necessary adjunct to metalworking practice. In this, too, wire has supplanted other, more con-

ventional, methods. Metal spraying, welding, brazing and soldering are among the primary uses of wire as a tool to achieve more rapid production, lower costs, and better quality products.

Examples such as these are only a few of the many available to demonstrate the use of wire as an engineering material. The ultimate use of this versatile material is limited only by the ingenuity and inventiveness of thought that lies behind each uct application; by the metal from the wire is initially made; and method of forming or fabricating t into the manufactured part.

Forming and Finishing Techniques

Wire as an engineering material is suitable for virtually all fabricating operations. Of course, not all wire materials are suitable for all fabricating methods since certain inherent properties, sizes, tempers, finishes, shapes, and the like may restrict specific wires from certain forming techniques. Basically, however, wire is suitable for redrawing, cold heading, hot heading, extruding, threading, riveting, knurling, edgewise winding, flat rolling, braiding, slotting, tapping, spinning, turning, weaving, drilling and stranding operations. In the majority of these operations, special dies, jigs, fixtures or tools are necessary to produce the final product in which the wire is used.

Two major methods of manufacturing wire forms or configurations are usually used, namely, the cold winding or forming process and the hot forming process. Generally speaking, the hot forming process is used for stock ranging upwards from ½ in. dia. When using wire smaller than ½ in., the cold forming process is most frequently used.

Cold formed configuration consists of continuously feeding wire, while cold, into automatic machines of various kinds. Each machine automatically forms the desired shape with the utmost precision and uniformity; the general excellence of the work being dependent upon the adjustment of the various tools, dies and cams which make possible proper automatic operation of the equipment.

The process of producing hot formed configurations differs from the usual cold forming method in that the material is first heated above its critical point and then formed in this condition. Subsequent heat treatments are performed to impart the proper physical properties if spring action is desired in the finished part. The hot forming process is not continuous, but includes a number of individual operations. Suitable stock is cut into correct lengths, placed in a furnace and heated to forming temperature. After heating, the stock is removed, piece by piece, and formed individually in the operational sequence.

Flattening, notching, coiling, pointing and grinding operations are often performed in sequence on a single machine for certain wire products. To accomplish this, several types of special and unique attachments or fixtures are used. Needless to say, the production rates achieved on operations of this sort are tremendous and a minimum amount of material handling, labor and maintenance is required once the setup has been completed. In operations of this type, the wire material is fed from coils into the machine, the finished parts emerging into chutes or bins ready for any final polishing, plating or lacquering that might be required.

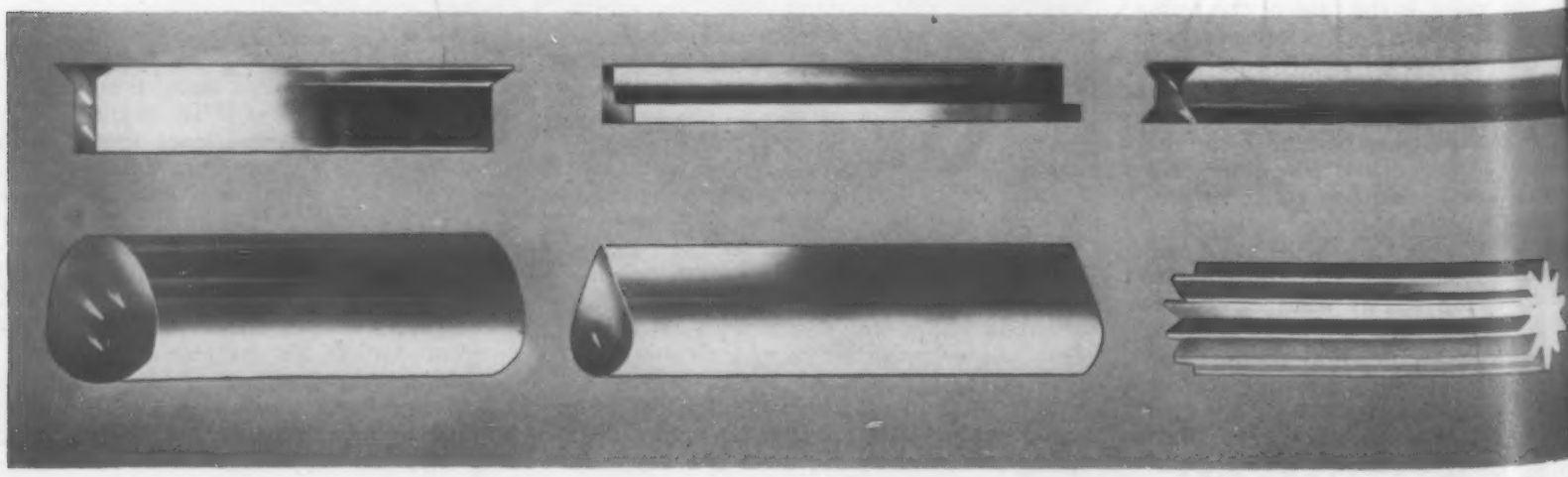
Surface finish is an important consideration in the manufacture of any wire product, since the surface of the wire will affect its practicability to corrosion resistance, welding, cold heading, extrusion, enameling, electroplating, crimping, forming, and the like. Wire finishes are generally classified into two groups: metallic and nonmetallic. The metallic finishes include zinc, copper, tin, and other such coatings or plates. The nonmetallic finishes include various degrees of surface smoothness and, in some cases, color, too. Nonmetallic finishes vary with the cleaning, drafting and lubrication practices used, and include the many heat treatments that are often used during and after drawing to secure certain desired physical properties.

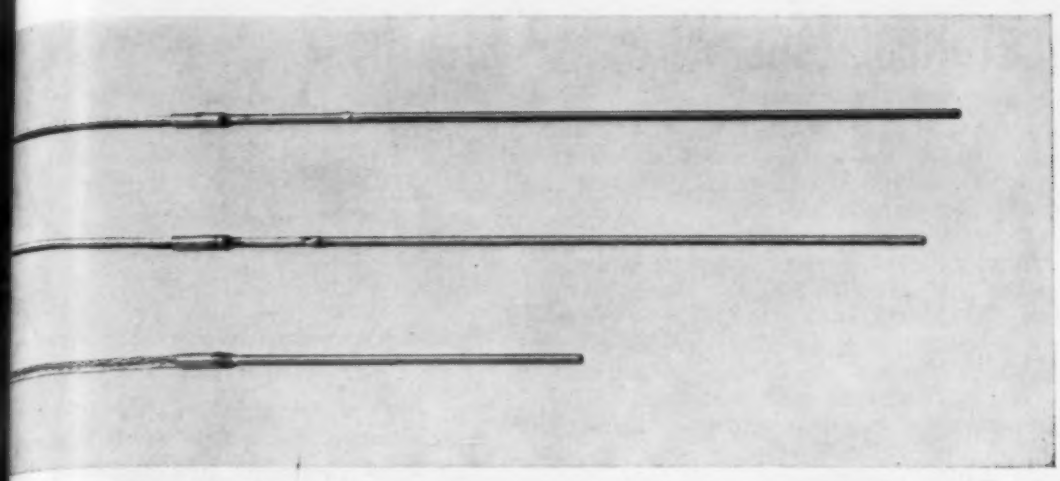
The most common heat treatment used is annealing, which softens and increases the ductility of the wire. Various proc and equipment are utilized, dependin the degree of softness required a amount of scaling or oxidation per Wire can be merely passed through fired furnace and cooled in the ai separate step in a series of fabricating tions. This method is simple and in sive, but there is an appreciable amo scale formed and softening is not as g it would be if the metal were cooled s Heating the wire by electrical resista in hot molten lead instead of the ope nace atmosphere decreases the amo scaling, but if the wire is again air c the resultant softness is much the There are several ways in which to de scaling and increase cooling control th customarily used to obtain varying d of softness or type of microstructure. include a "low" temperature molten l salt pot in tandem with a high temper unit so as to permit rapid cooling o wire to a selected level and bring abo formation of certain soft microconstitu

Some wire is hardened and toughen heat treatments for use in springs and products requiring similar character The wire is heated in much the same w that for annealing, but the wire is c rapidly instead of slowly by running tanks of water or oil. The quenched w then usually tempered by passing it i tank of hot oil or lead.

Irrespective of the forming and fini techniques used, however, any wire c uration or use, to be well designed executed, requires a careful considerati the basic materials from which it is m It obviously avails nothing if a precise gineered design is carried out in a ma which is unsuited to the purpose and to withstand the service loads or oper conditions to which it is subjected. It this reason that the various materials which wire and wire products are tomarily made are discussed in the next following sections of this presentation.

Typical of the cross-sectional forms in which wire is customarily drawn, these examples show the inherent savings that are to be achiev through the use of irregularly shaped wires. All of these wire forms, when cut off to the desired length, produce component parts th replace the costly machined and finished components that would otherwise be necessary if made on an individual basis from convention stock. The variety of cross-sectional shapes available are almost unlimited, and contribute much to the overall versatility that wire h achieved. (Courtesy American Steel & Wire Co.)





To achieve a permanent, leak-proof electrical connection through the borosilicate glass used in electronic tubes, these leads consist of a short length of centerless-ground tungsten rod welded to a length of stranded copper or nickel-clad copper wire at one end and to a length of nickel wire at the other end. At the copper end, a nickel sleeve is used because tungsten and copper both weld to nickel, while tungsten does not weld directly to copper too readily. At the other end, the tungsten is welded directly to the nickel. Tungsten is used primarily because its coefficient of expansion is almost exactly the same as that of the borosilicate glass. This application shows the relative versatility of wire as an engineering material for uses where unusual requirements are to be met. (Courtesy Fansteel Metallurgical Corp.)

Carbon Steel Wire

Regular carbon steel wire has great acceptance where low cost, high strength and extreme flexibility are factors in the manufacture of various wire products. Its composition is basically iron with definite amounts of phosphorus, manganese, copper, carbon, sulfur and silicon added to meet the high quality of standard commercial analysis for open hearth and electric furnace steels.

The tensile strengths of steel wire range from 50,000 psi. to 175,000 psi. and enable a manufacturer to select a wire advantageously—from one with great ductility to one with extremely high strength with no weight loss or gain.

Common annealed wire, customarily used where a soft, ductile product is required, is produced by drawing low-carbon wire to the finished size from the rod and annealing in pots or salt bath. When an especially soft wire is required which also must have a cold-drawn finish, it is general practice to anneal in process. In this, the wire is drawn from the rod to within approximately 1/64 in. of the desired finished size; annealed in pot or salt; and then cleaned and drawn to desired size. Wire of this type is known as process-annealed or processed wire.

The above treatments are generally associated with low-carbon steels. When it is necessary to produce a medium, or high-carbon wire with the highest degree of ductility and softness possible, spheroidizing is generally used. Cold-heading wires, in the medium or high carbon grades, or medium carbon alloys which must withstand excessive amounts of upsetting, are usually spheroidized in process.

The heat treating processes thus far explained apply generally to wires under 0.40% carbon. Steel wires of higher carbon content must necessarily be subjected to a somewhat different heat treatment in order to achieve desired results. This treatment is known as patenting and produces a desirable combination of high tensile strength and toughness. Patented wire will withstand appreciably greater percentages of reduction in cold-drawing than either the hot-rolled or annealed types and will have far superior physical properties. Spring wire, rope or cable wire, and music wire are probably the most important types of wire produced from patenting.

For general-purpose springs which are not subjected to any severe and continuous fatigue stresses in service, it is usually customary to use the hard-drawn wire as produced from the patented product. After coiling, such springs are generally baked at approximately 550 F, in reality an aging treatment, which increases the elastic limit of the metal about 5 to 10%. High grade mechanical springs are generally coiled from heat treated spring wire, usually referred to as oil-tempered wire.

A hard-drawn spring wire of high surface quality is oil-quenched from a temperature slightly above the critical point, followed by tempering in molten lead. Such wire, when compared with the hard-drawn spring wire, shows an appreciably higher bending yield point and, consequently, the coiled spring shows more resilience. Most of the automobile valve springs are produced from Swedish spring wire, due to the exceptional freedom of fine surface defects which so materially reduce the fatigue life of the springs in service.

Unfortunately, however, carbon steel wire does not possess a high degree of resistance to corrosion by water, oxygen, heat and acids, thus making final finishing or coating a necessity for applications subjected to exposure.

Alloy Steel Wire

To overcome the obvious disadvantages associated with the various grades of carbon steel wire and at the same time achieve a material that will withstand the ravages of corrosion without loss of strength, several alloys of steel have been developed in wire form from which myriad industrial products can be made. The addition of these alloying agents results in physical characteristics that far surpass those of the unalloyed metals.

Paramount among the alloy steels are those of the stainless variety. Wires in these grades commonly fall into two major groups: (1) the chromium-nickel, and (2) the chromium categories. Group 1 wires fulfill most general requirements, with the standard 18:8 or austenitic grades (Types 302 and 304) enjoying the most widespread use. These wires are not hardenable by heat treatment, but attain their tensile strength by cold working. Due to the difference in carbon content, Type 302 can be drawn to a somewhat higher tensile strength than Type 304, but for the same reason cannot be annealed to as soft a temper. The tensile range of Type 302 is from 120-135,000 to 250-350,000 psi., while the range for Type 304 is from 105-120,000 to 240-330,000 psi.

Another 18:8 variety of stainless steel wire in the chromium-nickel group is Type 316, which has an addition of molybdenum to make it the most corrosion resistant of the stainless alloys. Essentially austenitic in structure, it is slightly magnetic under certain conditions. It is available in a tensile range of 120,000 to 250,000 psi. Like Types 302 and 304, it is not heat treatable, but depends on cold working for the higher tensile strengths.

The wires in group 2 are largely the straight chromium type and are classified into two subordinate categories on the basis of hardenability: martensitic and ferritic.

The martensitic wires develop high values of tensile strength and hardness when cooled rapidly from 1700 to 1850 F, the resulting structure being similar to that of a hardened plain carbon steel. By proper heat treatment, it is possible to develop a wide range of mechanical properties, from 75,000 psi. tensile with 25% elongation to more than 250,000 psi. with 5% elongation.

Ferritic stainless steel wires do not harden when cooled rapidly from a high temperature. They are also slow to work harden and are, therefore, desirable for cold heading operations on such manufactured products as rivets, screws, bolts, automotive trim, and other accessories. Their corrosion resistance is better than that of the hardenable martensitic steels.

Typical of the ferritic group is Type 430, which does not respond to heat treatment. Its resistance to nitric acid is noteworthy and is commonly used for applications requiring this characteristic.

In general, the stainless steel wires are much more resistant to cold working than straight carbon steels but are more abrasive on forming tools, rolls and guides, etc. Stainless wires, however, are finding increasing acceptance in an ever-widening field of applications.

Corrosion Resistant and Heat Resistant Wire

To fulfill the need for wires able to withstand exceptionally corrosive conditions or repeated heating without loss of desirable characteristics, several alloyed wires have been developed to suit particular needs. Typical of these is Monel wire, an alloy form consisting of approximately 67 nickel and 30% copper, which has many unusual and highly desirable characteristics including: co[redacted]resistance to a wide range of acids, alk[redacted]nd salts; high mechanical strength comparing favorably with some of the alloy steels and far superior to the bronze, brass and nickel-silver alloys; and inherent ductility and toughness to a marked degree.

Monel is more resistant to reducing conditions than nickel and more resistant to oxidizing conditions than copper. The thin nickel oxide film on the surface of the wire passivates the alloy coupled with the high nobility of the copper content and makes this alloy one of the most universally useful of all the malleable metals.

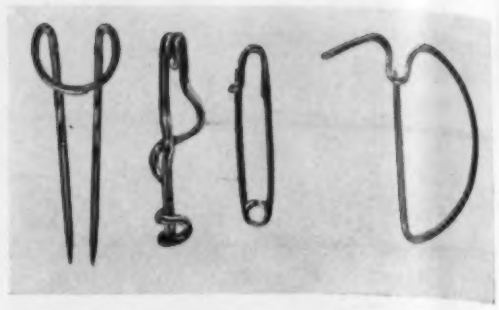
Monel wire is used extensively for high pressure filter cloths and strainers, handling such products as chemicals, paints, soaps, pharmaceuticals, dyestuffs, food, fruits, etc., at high or low temperatures. One of the most important commercial applications of Monel wire is in pickling baskets for metals immersed in hot dilute sulfuric acid and for cleaning fruit in dilute hydrochloric acid.

Monel wire possesses a good range of physical properties, ranging from 70,000-85,000 psi. for annealed wire to 170,000 psi. for hard-drawn wire. It resists wear and has high resistance to mechanical fatigue. It is pliable and can be readily worked or configured without difficulty.

Other heat and corrosion resistant alloys commonly used in wire form are Inconel, nickel, "Z" nickel, and "K" Monel. This last, "K" Monel, is similar to that described above except that its composition is 68 nickel, 29 copper and 2¾% aluminum. It is a nonmagnetic alloy with high spring properties and excellent corrosion resistance. "K" Monel is heat treatable, and can be used at high temperatures under fairly high stress.

"Z" nickel is a 98% nickel alloy that is heat treatable with excellent spring properties plus the corrosion resistance of pure nickel. "Z" nickel has good electrical conductivity and is moderately magnetic. Temperatures up to 400 F have little effect on its properties. Its strength is 2½ to 4 times that of structural carbon steel.

Nickel wire has the highest electrical conductivity of this group of metals and is moderately magnetic at ordinary temperatures. One of its most useful properties as a corrosion resisting material is its almost complete resistance to alkalies. The use of nickel wire, however, is limited to dilute solutions of oxidizing acids and salts such as ferric chloride, mercuric chloride, mineral acids with chromates, dichromates and nitrates in solution, and sulfuric acid. It is easily worked and withstands high temperatures.



Replacing components often comprising two or more parts, these examples of complicated wire forming and pointing applications are representative of wire's versatility in the production of configured pins or shapes. Such applications are customarily made from brass or steel wire in one complete operation. The wire is taken from the coil, straightened, pointed and formed in a sequence of automatic operations that result in an extremely low cost, high output product. (Courtesy Risdon Manufacturing Co.)

Inconel is an 80 nickel, 14 chromium, 6% iron alloy that is heat resistant for applications at high temperatures. Inconel wire is also resistant to corrosion by a wide variety of chemicals, and is readily worked or formed for many applications. Inconel possesses a desirable combination of high strength and workability, both hot and cold. Tensile strength varies from 80,000 psi. for cold drawn to 185,000 psi. for small diameter spring temper wire.

Copper and Copper-Base Alloy Wire

Wire of copper and its alloys offers to the manufacturers of a great variety of products a wider range of versatile and useful characteristics than any other group of metals. There are literally hundreds of different copper alloys available in wire form for commercial use, each of which is available in a wide range of tempers and corresponding physical characteristics. For most applications, however, a selected number of standard alloys is entirely adequate. Since there is no one wire which meets all requirements, the selection of the proper composition for a specific use depends upon a compromise of the characteristics required. Many factors must be considered and a choice of the most suitable material may be difficult. The dominant consideration may be workability, machinability, strength, hardness, electrical and thermal conductivity, resistance to corrosion or wear, availability, cost, or a combination of these. Characteristics of the basic copper and copper-alloy wires are discussed below.

Copper Wire

Standard copper wire has a minimum of 99.9% copper content and is the best conductor of electricity and heat of the commercial wires. Because of this, it is widely used for the transfer of electrical current with low electrical resistance and as an integral part of various types of heat-dissipating equipment.

The exceptional resistance of copper wire to corrosive waters, salts, acids and alkalies (with the exception of moist ammonia and ammonium compounds) has made it likewise useful for many chemical and process industry applications. Copper wire, exposed to oxidizing conditions, takes on a satiny green patina which, when once formed, prevents further action. The resistance of copper in wire form to acids and waters is largely dependent upon the amount of oxidizing salts in solution, the temperature, and the degree of aeration present. Nitric acid, cyanides, and ferric compounds are corrosive to copper wire, and care should be exercised in its use near these.

Copper wire has a strong tendency to become brittle when subjected to reducing atmospheres for any length of time. Soft copper wire has a tensile strength of 30,000 psi. and can be welded, brazed or soldered. Intricate configurations are possible, and its extreme workability, in addition to its ductility and wear resistance, extend its potential applications considerably.

Brass Wire

All brass wire is composed mainly of copper and zinc, with small percentages of such metals as lead, tin and aluminum added to improve certain properties for specific applications. The main difference between the various brass alloys used in wire form is in the ratio of copper to zinc, such as 80-20 copper zinc (low brass) and 70-30 copper zinc (high brass).

In applications using brass wire, where hardness is desired, the higher zinc content alloys are generally recommended, whereas the corrosion resistance increases in proportion to the copper content. There is, however, one exception to this: sulfur compounds readily attack copper; and usually the higher the zinc content, the better the resistance to corrosion. Those copper wires which contain less than 80% copper are sometimes subject to corrosion in which the zinc is selectively removed from the alloy, leaving a porous copper mass. This type of corrosion is called "dezincification" and is common where brass wire is used in corrosive waters or in contact with acids.

Brass wire is, in most instances, annealed before fabrication as an aid to the forming of such configurations as are required. The tensile properties vary from annealed to hard, and the fully annealed state is regulated by the grain size. Tensile strengths range from 50,000 psi. to 120,000 psi. for most high- and low-brass wire. High-brass wire is used extensively for such applications as springs, pins, strainers, jewelry, and the like. The low-brass applications include filters, screens, staples, bindings, chains, pins, brushes and rope.

Phosphor Bronze Wire

Phosphor bronze wire is an alloy of copper and tin deoxidized with phosphorus. The outstanding characteristics of this alloy wire are its high resistance to corrosion; the negligible effect of even considerable rise of temperature upon its mechanical properties; its extraordinary strength and toughness; its resistance to repeated stresses and corrosion resistance simultaneously with fatigue; its high resiliency; and its minimum tendency toward season cracking. The wire is particularly useful where strength,

endurance and high resistance to wear are required, and is customarily used extensively in conveyor belts, transmission belts, and the like.

A particularly heavy tonnage of phosphor bronze wire goes each year into the manufacture of springs and similar configurations. A special feature of this stock is the fact that, after having been formed into the shape or configuration required, the ends can be readily formed into connections without annealing. This, obviously, not only saves annealing time, but also allows the wire configuration to retain its original resiliency.

Since phosphor bronze wire is not subject to "arcing," it is highly dependable for electrical uses where complications would otherwise occur were it not for this important feature.

Phosphor bronze wire forms well and can be easily drawn, twisted, notched, pierced or flattened. Parts fabricated from this versatile wire can be cleaned and tumbled readily, and take a high polish.

Typical uses for this wire customarily include springs, staples, cables, screens, strainers, ring travelers and fish lines. In these applications, phosphor bronze wire offers excellent resistance to rural, industrial and marine atmospheres, but when used in contact with food and its acids, the wire should be tin coated, not so much for resistance to corrosion, but to avoid contamination of the food.

Commercial Bronze Wire

Commercial bronze wire is a brass composed of a binary compound of 90 copper and 10% zinc. This alloy wire has a very true bronze color with outstanding resistance to most corrosive mediums affecting the brasses. "Dezincification" is not serious in rural, industrial and marine atmospheres, and hence, commercial bronze wire coated with tin can be used to advantage in the food industry. Sulfur compounds and gases attack this wire more readily than brass with a greater zinc content.

Commercial bronze wire is more ductile than 80-20 brass and can be easily fabricated with a minimum of difficulty. The wire can be brazed, welded or soldered, although galvanic corrosion occurs if this alloy is joined with the less noble metals such as zinc steel, stainless steel, lead or aluminum if there is present a liquid having good conducting properties.

Beryllium Copper Wire

The development of beryllium copper wire was hastened in a large part by the recent war, and wires of this alloy have proved in many ways to be the answer to a number of troublesome problems. The wire has excellent corrosion resistance, outstanding fatigue properties, and withstands vibration in a remarkable manner. This alloy has unusual resistance to loss of physical properties at elevated temperatures as compared to other copper-base alloys.

The primary feature of this wire that makes it so valuable is the fact that it can be hardened after forming. As a result, its applications cover a wide field and range from hairsprings, ring travelers and electrical contacts to brushes, conductor cords and fishhooks.

The corrosion resistance, high strength and easy formability in the unheat treated state and a negligible degree of creep or hysteresis are also qualities which make this wire, when properly heat treated, useful and adaptable to many product applications.

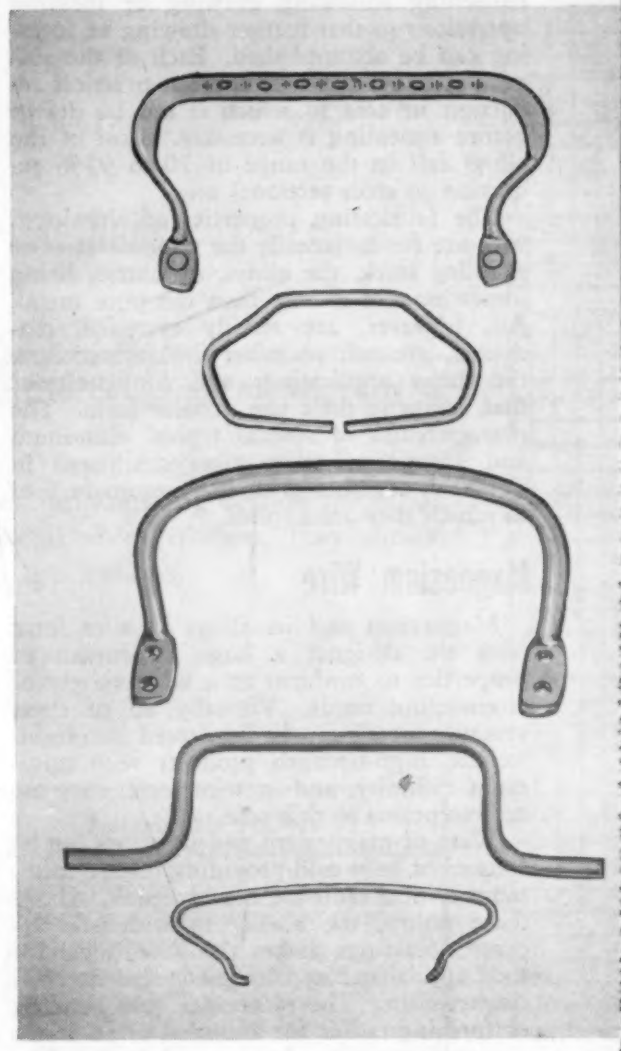
The tensile strength of this wire ranges from 80,000 to 100,000 psi. in the commercially available condition. When precipitation hardened, the tensile strength rises to 150,000 to 180,000 psi.

Nickel Silver Wire

Nickel silver wire, composed essentially of copper, zinc and nickel, is a lustrous white color and, because of this coloring, the wire is in steady demand for spectacle frames, jewelry, pins, and similar objects requiring a pleasing, yet durable, appearance. The wire possesses a high degree of corrosion resistance; this resistance, exceeding that of brass with a like copper content, increases along with the nickel or copper content of the alloy.

In the soft tempers, nickel silver wire is extremely ductile and malleable. Any degree of temper up to the extremely hard tempers can be obtained. In the harder tempers, the wire has a relatively high tensile strength, reaching, for example, in spring wire approximately 145,000 psi. This makes it an excellent material for the fabrication of parts which must be small in thickness or diameter, yet capable of bearing considerable stress. The wire can be swaged, forged, hard or soft soldered, spot or arc welded, and is readily adaptable to ordinary methods of fabrication.

It can be used for a wide variety of product applications. Included among these are slide fasteners, jewelry, chains, optical equipment, springs, keys, musical instruments, and various types of decorative trim.



Formerly made as stampings from sheet stock and subjected to a great variety of machining, tumbling, polishing and finishing operations, these handles are now made as simple configurations from wire stock in either round or irregular cross-sectional shape. This method of manufacture results in a lower cost product because of the savings that accrue in material waste, production economies, and labor time. (Courtesy Eastern Tool & Manufacturing Co.)

Light Alloy Wire

The rise in the use of the so-called light metals for many engineering applications has been no less than phenomenal during the past decade. Spurred by the war, these metals have been applied to many uses wherein their inherent advantages of greatly reduced weight, high corrosion resistance, ductility, and the like have far overshadowed those of more conventional materials. These metals, in wire form, have paralleled this rise. Present indications portend an even greater use for light metal wires as still newer uses are devised and applied.

Aluminum Wire

Aluminum, in wire form, is supplanting other materials in a growing number of applications primarily because of its excellent corrosion resistance, low specific gravity, high electrical conductivity, pleasing color, range of possible mechanical properties, workability, and similar desirable factors. Wires of this metal and its alloys can be produced with tensile strengths ranging from 13,000 psi. in the annealed, commercially pure state to more than 80,000 psi. in the solution treated and artificially aged 75S variety. Many other alloys and tempers fall between these two extremes. With the exception of rivets, nails, and a few other applications, the greatest tonnage of aluminum wire is produced in alloys requiring no solution heat treatment and which acquire their mechanical properties through cold drawing alone.

Aluminum wire is drawn on conventional equipment. One characteristic of the wire, however, is its suitability for drawing from rod to finished size without any intermediate cleaning or coating operations. Some of the aluminum alloys can be drawn in the as-rolled condition, others are generally softened by annealing at rod size before drawing. Drafting follows approximately the same pattern as for other metals. Reductions of 30% per pass are used above approximately 0.156-in. dia. and one Brown & Sharpe gage number reduction per pass for sizes under 0.156-in. dia.

As mentioned above, a large proportion of aluminum wire tonnage requires no final heat treating operation, the desired properties being obtained by controlling the reduction following an intermediate anneal or by annealing at final size if dead soft material is required. Most of the aluminum wire alloys are annealed at 640 to 675 F. In this range, recrystallization is instantane-

ous and soaking is unnecessary if all the stock has reached the required temperature. After annealing, the wire should be permitted to cool naturally in air.

Annealing is necessary not only to control final properties but to remove strain hardening following drawing or forming operations so that further drawing or forming can be accomplished. Each of the aluminum alloys has a maximum practical reduction in area to which it can be drawn before annealing is necessary. Most of the alloys fall in the range of 70 to 95% reduction in cross sectional area.

The fabricating properties of aluminum wire are fundamentally the same as those of as-rolled stock, the alloys, of course, being somewhat less ductile than the pure metal. All, however, are readily extruded, machined, ground, or otherwise formed into the many applications and configurations that comprise their use in wire form. The characteristics of several typical aluminum and aluminum alloy wires are listed in Table V, together with the customary uses to which they are applied.

Magnesium Wire

Magnesium and its alloys in wire form offer the designer a large assortment of properties to conform to a wide variety of engineering needs. Virtually all of these versatile metals can be fabricated into lightweight, high-strength products with minimum difficulty, and in wire form, they are no exceptions to this rule.

Wire of magnesium and its alloys can be formed or bent cold providing certain minimum critical radii are not exceeded. Above these points, the ability to withstand repeated bendings makes the wires ideal for such specialized applications requiring this characteristic. The minimum cold bending or forming radius for annealed or as drawn magnesium wire is approximately four times the section thickness. At broad and non-critical elevated temperatures, magnesium alloy wires become very plastic and susceptable to working far beyond the limitations of most other metals, since they have the advantage of a non-critical metallurgical structure without heat treatment and suffer in substantial loss from repeated heating.

Simple wire configurations of magnesium and its alloys can be made cold, but for more complex shapes or designs, heating is recommended. Heating can be done in ovens or locally with flames or torches. Forming dies can be cold if the metal is given enough superheat, or if the operation requires only a short interval of time, but for most practical results, the dies should be heated. Attempting to supply heat to the metal from dies above is bad practice and is a normal cause of failure in complex operations.

In the forming of magnesium wires, only light tools and dies are required because of the extreme workability of the metal. These tools can be of magnesium, aluminum, steel or cast iron. If not too highly heated, they can be of rubber or zinc alloys.

Single drawing or forming operations can often be made on magnesium wires that would require several operations with other metals. This, in addition to the fact that spring-back, intermediate annealing and reheat treatment as practiced with aluminum alloys can be avoided by working at elevated temperatures, points up large operational, labor, and equipment savings when working with these versatile metal forms.

Precious Metal Wire

The precious metals—gold, silver, platinum, rhodium, iridium, etc.—possess many characteristics that make them indispensable for many industrial and commercial applications. In wire form, these metals can be effectively utilized to take maximum advantage of their inherent characteristics.

Among the chief advantages of these metals is their susceptibility to fine drawing. This, together with their superlative corrosion resistance, electrical conductivity, extreme workability, and long wearing qualities, offers a unique combination to meet the varied demands of the electrical, mechanical and chemical industries.

Since cost, however, is perhaps the biggest single drawback to the widespread use of these valuable wires, considerable progress has been made in effectively laminating the precious metals to base metals of relatively lower cost. The laminated wire is essentially a shell of precious metal in which a core of base metal has been bonded, rolled and drawn to the required diameter. In this lamination, the ratio of precious metal to base metal can be predetermined and held to remarkably close tolerances. The proportion of precious metal to base metal always remains the same and the color, temper or finish is easily controlled through the lamination process. Laminated wire can be customarily drawn to diameters as fine as 0.005 in., with the thickness of the precious metal lamination held to a tolerance of 0.0001 in. In spite of such small dimensions, wires like this are often subsequently engraved for decorative purposes or shaped into configurations for industrial use.

Laminated wires, available in a wide variety of cross-sectional shapes, are commonly used in spectacle frames; in various instruments; for formed and plated springs; for low-cost electrical conductors (silver coated steel); for radio electronic parts; where expansion must be held to a minimum (silver on invar); and in chemical apparatus where corrosion must be prevented. During the war, such specialized fabrications as collector rings, radio and radar parts, aircraft instrument parts, firing pin supports for bombs, fire control instrument parts, and innumerable similar applications were made from both solid and laminated precious metal wire. In peacetime, their applications are no less numerable.

Conclusion

From this discussion of the materials from which wire is customarily drawn and from the basic considerations of wire characteristics and their forming and finishing techniques, the materials engineer is able to get an over-all picture of the stature wire has achieved as an engineering material. In its basic form it has become a valid adjunct to the field of materials specification equally as much so as the conventional plate, round, bar and sheet forms in which engineering materials are usually obtained. In this useful form, wire possesses many advantages over other materials stock—advantages, as have been shown, that result in tremendous savings in materials costs and production time and expense. In addition, the products resulting from the use of wire forms have been improved from the standpoint of consumer acceptance. In light of this, it behooves the materials engineer to reconsider his own particular materials selection with a view toward achieving the same desirable gains as those obtained by the examples set forth herein.

Acknowledgment

Acknowledgment is made for the assistance given in the preparation of this manual by the following organizations:

Acme Steel Co.
Alloy Metal Wire Co., Inc.
Alpha Wire Corp.
American Brass Co.
American Steel & Wire Co.
Art Wire & Stamping Co.
Atlantic Wire Co.
Baker & Co.
Belden Manufacturing Co.
Bostitch, Inc.
Bristol Brass Corp.
Broderick & Bascom Rope Co.
Buffalo Bolt Co.
Bussman Manufacturing Co.
Carpenter Steel Co.
Chase Brass & Copper Co.
Chase-Shawmut Co.
Clendenin Bros., Inc.
Collyer Insulated Wire Co.
Colorado Fuel & Iron Co.
Columbia Steel Co.
Continental Steel Corp.
Copper & Brass Research Assn.
Copperweld Steel Co.
Diamond Wire & Cable Co.
Driver Co.; Wilbur B.
Electric Auto-Lite Co.
Essex Wire Corp.
Fansteel Metallurgical Corp.
Flexo Wire Co., Inc.
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Johnson Steel & Wire Co.
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Makepeace Co.; D. E.
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National Standard Co., Athenia Steel Div.
New England Electrical Works, Inc.
North American Philips Co., Inc.
Okonite Co.
Prentiss & Co.; George W.
Radix Wire Co.
Rathbone Corp.
Rea Magnet Wire Co., Inc.
Revere Copper & Brass, Inc.
Reynolds Wire Co.
Risdon Manufacturing Co.
Riverside Metal Co.
Rome Cable Corp.
Seymour Manufacturing Co.
Simplex Wire & Cable Co.
Sleeper & Hartley, Inc.
Sylvania Electric Products, Inc.
Triangle Conduit & Cable Co., Inc.
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United States Rubber Co.
Varflex Corp.
Whitehead Metal Products Co., Inc.
White Metal Rolling & Stamping Co.
Whitney Blake Co.
Wilson Steel & Wire Co.

Materials Engineering File Facts

NUMBER 193
June, 1950

Selecting Rubber Compounds and Processing Methods

Mechanical and industrial rubber products are generally formed by molding, extruding or calendering followed by stamping or punching. Some of the factors which should be considered in designing rubber parts to be produced by these methods are presented in the table below.

In addition, it is possible to indicate to some extent the relative suitability of the different types of rubber compounds for various service conditions. Since many factors are involved in the compounding of raw materials, the comparisons presented on the next page must be considered broad and general. Nevertheless, they should assist the engineer in the preliminary selection of rubber compounds for specific applications.

Processing and Fabricating Rubber Parts

Process	Favorable Factors	Unfavorable Factors
MOLDING **Molding is the process of producing articles to a particular and definite shape through formation in cavities and vulcanization under heat and compression. For economical production, molds are usually constructed from steel and contain multiple cavities, the number depending upon the size of the article to be reproduced. Such items as grommets, bushings, recess bumpers, suction cups, etc., are made by the molding process.**	1. Uniformity. 2. Close tolerance. 3. Good finish. 4. Almost unlimited in adaptability to contour design.	1. High cost of mold equipment. 2. Production limited by size of mold and by press size. 3. Higher cost of finished parts.
EXTRUDING **Extruding is the process of producing articles to a particular and definite shape by forcing raw stock (by means of a worm or screw drive) through dies and cutting the formed section in lengths. These extruded lengths are then vulcanized under open steam in specially designed heating chambers.**	1. Low set-up and die cost. 2. Low finished part cost. 3. Extruded strips can be cut to length and vulcanized endless to form gaskets, etc. 4. Extruded tubes can be cut in short sections by hand or automatically to form simple gaskets, bushings, spacers, tubes, etc.	1. Moderate tolerances required. 2. Considerable design limitation. 3. Limited to durometer "A" hardness between 40 and 85. 4. Limited in size to about 4-in. maximum dia.
CALENDERING **Calendering is the process in which raw rubber stocks are fed through a series of steel cylinders parallel-mounted in a vertical bank. The space between rolls can be adjusted accurately so as to build up proper gage. After the sheet stock has been run through the calender, it is vulcanized in a hot room or cured in long vulcanizing presses. This sheet stock can be stamped or punched into practically any desired shape provided top and bottom surfaces are flat.**	1. Substantial daily production. 2. Uniformity of finished parts. 3. Nominal initial set-up charges. 4. Low cost per unit. 5. No quantity too large or too small. 6. Great flexibility of design and materials. 7. Minimum time before commencing production. 8. Usually many stock dies available which can be utilized without amortization expense.	1. Articles must be flat on both sides. 2. Wastage of material if article has large center or cut-out sections.

(Continued on page 85)

For the Production Engineer's Notebook—

Ideas for Welded Design

Product engineers, even the geniuses among them, find that the formula, "1% inspiration, 99% perspiration,"* pretty regularly applies.

Perspiration in design is brought about by the inevitable conflict between operating function—how well the part will do its job—and such other important factors as sales appeal, serviceability, and manufacturing methods.

What we are all striving for is to apply welding most economically. We in LINDE stand ready to help the product engineer in the applications of welding methods wherever we can. Sometimes economies in production come from a substitution of welding for more expensive methods, but often just a small change in design or practice reduces the cost of present welding operations.

Pointers on welded design leading to production economies.

Use the process that gives the greatest total economy.

Design for down-hand welding where possible. But locate welds so as to minimize handling.

Mechanize welding. Weld as many joints simultaneously as possible.

Make minimum dimension changes when making different sized models.

Reduce the number of parts. But sometimes it is better to increase the number of parts and cut rejects in intricate castings or forms by welding together simple forms.

Use standard shapes and easily formed sections.

Pointers on welding processes leading to production economies.

UNIONMELT welding: high speed process for deep-penetrated welds—minimum cleaning and finishing—no spatter, sparks, or smoke—usually mechanized—will make butt, tee, and lap fillets, plug, and molded welds. Used for most ferrous and many non-ferrous metals. Ask LINDE for booklet F-6077.

HELIARC welding: used for most metals, especially aluminum, magnesium, stainless steel, and copper alloys. Particularly useful for sheet steel. Manual or mechanized—high speed—greatest feature is minimized cleaning and finishing because of flux and spatter elimination. Ask for booklet F-6291.

Take advantage of other economies that are inherent in such oxy-acetylene processes as flame-cutting, welding, surfacing, hardening. For more information on any of these processes call or write to The Linde Air Products Company, offices in principal cities.

* "Genius is 1% inspiration and 99% perspiration," credited in GOLDEN BOOK, April, 1931, to a newspaper interview with Thomas A. Edison.

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Materials Engineering File Facts

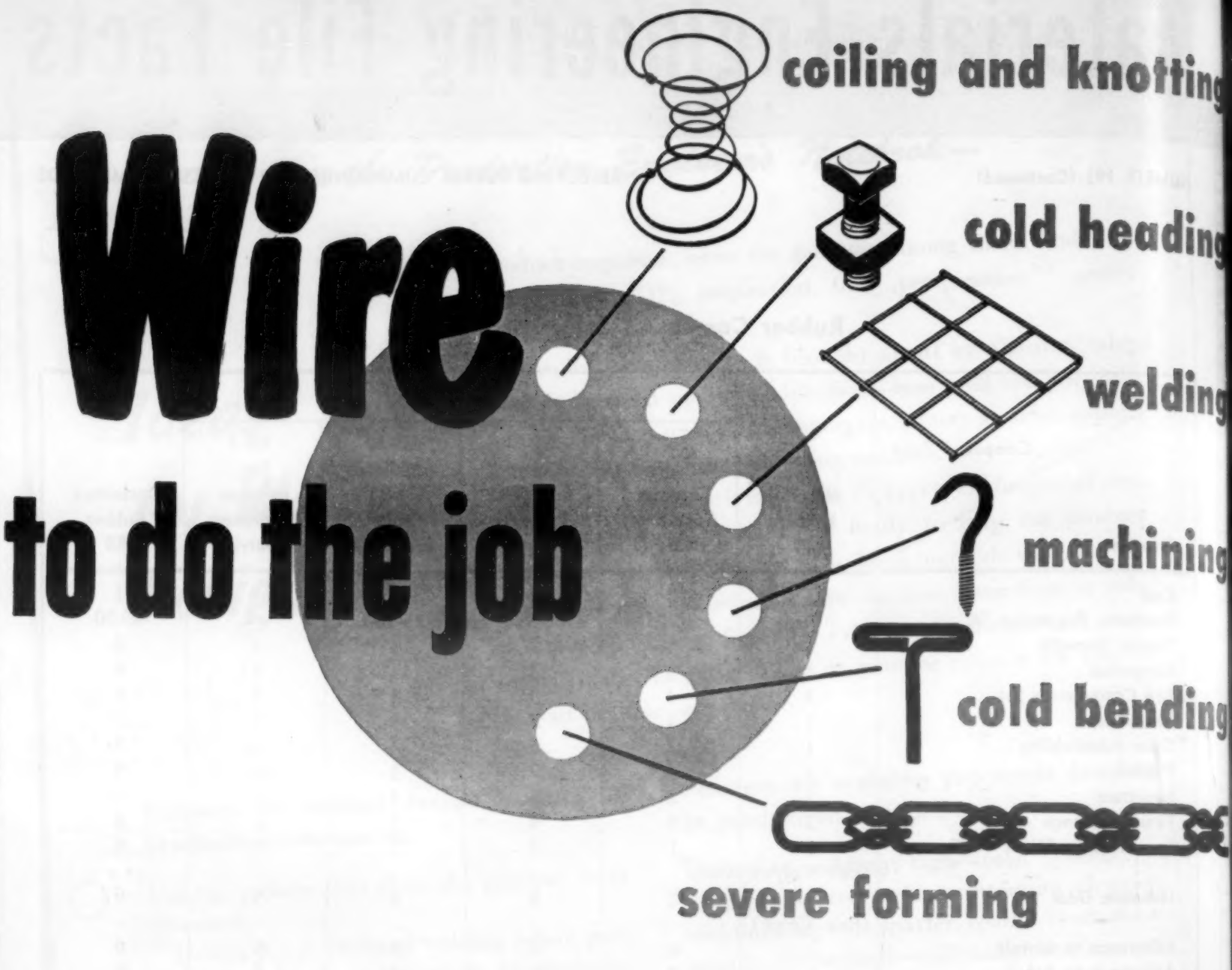
NUMBER 193 (Continued) SELECTING RUBBER COMPOUNDS AND PROCESSING METHODS

Rubber Compound Selection Factors

Property \ Compound Type	Natural Rubber NR	Synthetic Rubber: GR-S Butadiene-Styrene Copolymers (Buna S)	GR-M Chloro-butadiene Polymers (Neoprene)	GR-N Butadiene-Acrylonitrile (Buna N)	GR-I Iso-butylene Copolymers (Butyl)	Reclaimed Rubber RR
Cost	3	2	4	6	5	1
Hardness, Durometer "A"	20-100	30-95	25-100	25-100	—	40-90
Tensile Strength	1	5	2	3	4	6
Elongation	1	3	2	4	5	6
Low Compression Set	1	4	3	2	5	6
Resilience	1	4	2	3	6	5
Color Adaptability	1	2	3	4	—	5
Flexibility	1	4	2	3	—	5
Insulation	1	2	5	4	3	—
Tear Resistance	2	5	4	3	1	6
Low Staining Effect on Enamel	2 (Pale Crepe)	1	4	5	3	6
Minimum Odor	1 (Pale Crepe)	2	3	4	5	6
Adherence to Metals	1	4	2	3	5	6
Adherence to Fabric	1	2	3	4	6	5
Resistance to:						
Abrasion	1	4	2	3	5	6
Aging	5	4	1	3	2	6
Alcohol	2	4	3	1	—	5
Animal Fats	3	4	2	1	—	—
Acids (Weak)	1	5	2	4	3	6
Benzene	—	—	2	1	—	—
Cold (to 40 F)	1	3	5	4	2	6
Cold (to 70 F)	1	3	5	4	2	—
Carbon Dioxide	3	4	2	1	—	—
Carbon Tetrachloride	—	—	—	1	—	—
Ethylene Glycol	—	—	2	1	—	—
Flame	—	—	1	—	—	—
Freon	—	—	2	1	—	—
Gas (Natural)	3	4	2	5	1	6
Gasoline	—	3	2	1	—	—
Heat (to 180 F)	1	4	3	2	—	5
Heat (to 250 F)	4	3	2	1	—	—
Kerosene	—	3	2	1	—	—
Methyl Chloride	—	3	2	1	—	—
Moisture	2	4	5	3	1	—
Naphtha (Coal Tar)	—	—	—	1	—	—
Naphtha (Petroleum)	—	3	2	1	—	—
Oil (Vegetable)	1	4	3	2	—	—
Oil (Lubricating)	4	3	2	1	—	—
Prestone	—	3	2	1	—	—
Sunlight	5	4	1	3	2	6
Turpentine	—	—	—	1	—	—
Weather Aging	5	4	1	3	2	6

NOTE: No. 1 indicates the compound most favorable for each property, etc.

Adapted from data furnished by Lavelle Rubber Co., Chicago, Ill.



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BETHLEHEM STEEL

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New Materials and Equipment

Materials

Diamond Abrasives

A kit containing the six most widely used Bureau of Standards grades of Dymo diamond compound has been introduced by the *Industrial Products Div.* of *Elgin National Watch Co.*, Elgin, Ill. The Dymo Shop Convenience kit is intended to facilitate development work in the application of diamond abrasives. Potential applications include mass production finishing techniques, high precision lapping, plastic mold polishing, carbide tool sharpening, die finishing and metallurgical specimen preparation.

Six grades of Dymo diamond compound are contained in this new development kit.

Each Dymo grade in the kit is color identified and contained in jars with matching color tops. The jars are packed in a compact wood case with hinged lid.

Zircon Material

An intermediate-sized zircon product, featuring high purity and uniformity, has been developed for the ceramic and metallurgical industries by *Foote Mineral Co.*, 18 W. Chelten Ave., Philadelphia 44, Pa. Called Zirkatom, its particle size is intermediate between that of standard milled zircon and extremely finely ground, premium-priced opacifier grades.

It is expected to permit close shrinkage control in zircon porcelain and refractory bodies, faster solution in enamel frits and glasses, and finer grained foundry facings.

Heat Resistant Phenolic

A mineral-filled phenolic molding compound, called Durez 14893 Black, has been announced by *Durez Plastics & Chemicals, Inc.*, North Tonawanda, N. Y. It is claimed to feature high heat resistance, good finish, fast cure, and relatively low specific gravity. It also has good strength characteristics and is suitable for molding around inserts.

High-frequency preheating characteristics of Durez 14893 Black are similar to other mineral-filled materials. The plastic can be molded by either compression or plunger methods, its fast cure offering good molding economy.

Molded test pieces which have been baked 24 hr. at 450 F are said to have higher strength after the test and to retain their unusually high-gloss finish. The surface remains relatively unimpaired after 200 hr. at 450 F. Intermittent exposure to high temperatures is also safe.

Other properties include: specific gravity, 1.57 (average); water absorption, 0.20 ±0.01%; flexural strength, 7000 psi. (min.); impact strength, 0.26 ft. lb. per in. (min.); and distortion under heat, 340 F (min.).

Rigid Molding Resin

Production of Geon 400 X 65, a polyvinyl chloride resin having improved processing characteristics, has been announced by *B. F. Goodrich Chemical Co.*, 324 Rose Bldg., Cleveland 15, Ohio. This material is expected to stimulate the market for vinyl resins in rigid and semi-rigid applications.

Geon 400 X 65 can be extruded, calendered or molded in unplasticized form at temperatures under 300 F; its good heat stability for long periods makes it possible, through proper compounding, to produce transparent molding, as well as calendering and extrusion compounds. It can also be used to produce crystal-clear rigid sheet or piping. Low-viscosity cements can be formulated by dissolving the resin in solvent

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New Materials and Equipment
(CONTINUED)

mixtures of acetone and an aromatic component.

Like other vinyls, Geon 400 X 65 is unaffected by water, grease, oils, ozone, salts, alkalis, acids, oxidizing and reducing agents in fairly high concentrations and at relatively high temperatures. It is said to possess good flexural strength, high dielectric strength, good insulation resistance, good impact resistance and wear resistance superior to conventional rigid plastic materials. It is also non-inflammable.

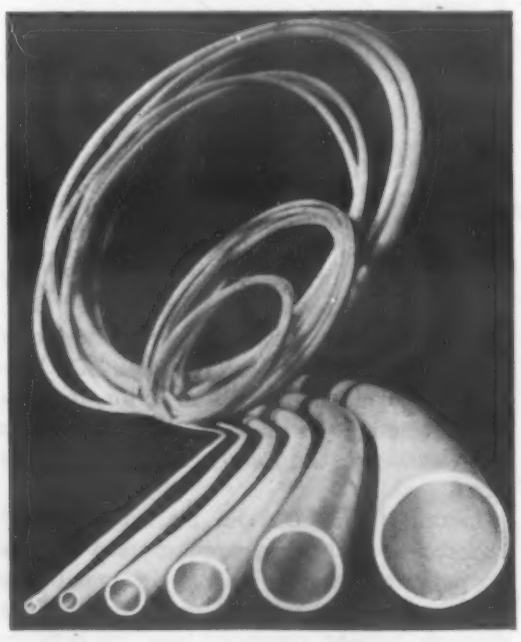
Some of the applications being considered for the new resin are phonograph records, rigid sheet and piping, and protective coatings and adhesives.

Parts & Forms

Plastic Tubing

Corrosion resistant plastic tubing designed especially for use in the chemical and food processing industries is now being made by *Carter Products Corp.*, 10235 Meech Ave., Cleveland 5, Ohio.

The translucent, flexible tubing, known as Carlon C, is extruded from plastics compounds containing no color pigments that could be absorbed by certain chemicals. In addition to its suitability for handling chemicals and corrosive gases, Carlon C can also be used in air conditioning and refrigeration equipment, instruments, radiant heating systems, and other applications.



Flexible Carlon C plastic tubing saves weight and resists corrosion.

One of the primary advantages of this plastic tubing is its extremely light weight. A 100-ft. length of ½-in. tubing weighs only 3.44 lb. Its light weight and flexibility eliminate the necessity for many fittings. Carlon C is available in seven standard sizes ranging from ¼- to 1-in. dia., and is furnished from stock in 100-ft. coils. Special coils up to 500 ft. can be supplied on order.

Stainless-Clad Copper Tubing

Cold-drawn seamless tubing of Rosslyn Metal, consisting of copper core with stainless steel surfaces, is now available from *American Cladmetals Co.*, P. O. Box 544, Carnegie, Pa. This tubing is expected to find wide application in freezing and heating units, particularly in the dairy industry.

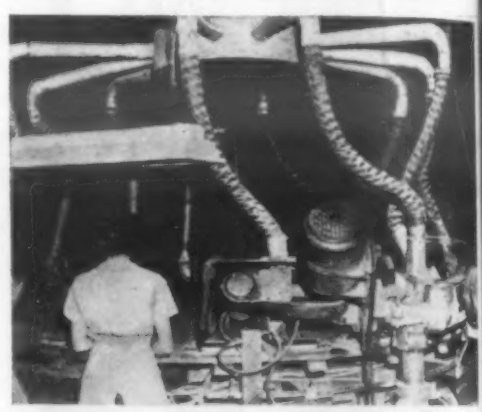
The seamless tubing is made by first drawing a tube hollow or tube billet from a flat sheet of Rosslyn Metal. Successive draws and anneals are used until a tube hollow 2⅜-in. O.D. by 18 in. long and approximately ⅛-in. thick is produced. This tube hollow is then redrawn by conventional methods to thin wall seamless tubing. Sizes available are from ⅜- to 1½-in. O.D. with wall thickness from 0.078 to 0.020 in. Maximum weight for a piece of tubing at the present time is 5 lb.

The stainless surfaces in Rosslyn Metal provide hardness, resistance to corrosion and ease of cleaning. The copper core, to which the stainless is permanently bonded, affords fast heat transfer. As a result, less of this tubing will have to be used for many applications than is used of conventional tubing.

Flexible Tubing

A lightweight, flexible tubing called Spiratube is being offered by *Flexible Tubing Corp.*, Branford, Conn. The retractable tubing is said to be highly wear and heat resistant, easy to assemble and able to withstand pressure or vacuum in many services.

Spiratube is designed to fill most ducting requirements from 3 to 30 in. I.D. for air and



Spiratube is suitable for most ducting requirements.

other gases, and for powdered, granular or other light solids. Construction of this tubing consists of a rust-proof spring-steel helical core, covered inside and out by double-seam stitched cotton duck, coated with Neoprene. Standard variations of this basic design employ multiple-ply walls and other types of coatings for a wide variety of applications.

Some of the characteristics of this flexible tubing (as determined for 8-in. I.D. tube) are: weight, 0.64 lb. per cu. ft.; retractability, from 15 to 23 ft.; strength, 170 psi or 25 in. mercury vacuum; durability, 280,000 flex cycles without noticeable wear; and heat resistance, –30 to 250 F and higher on special order.

Metal Powder Sheets

Large sheets of porous metal are now being produced by *Wel-Met Co.*, Kent, Ohio. The sheets measure 10 to 14 in. wide, 14 to 18 ft. long and 1/16 to ¼ in.

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Let us make it to fit the job exactly

Here in the mills of The American Brass Company, more than 100 different copper alloys are processed into wire in an almost unlimited variety of sizes and shapes, tempers and finishes. The result is that each wire is, in effect, tailor-made . . . especially adapted to particular problems of tooling, rate of production, and desired properties of the finished product. And there's a big difference—both in quality and unit cost—when the wire is exactly suited to the job!

The column at the right very likely holds the combination to that "one best wire." Our Technical Department will help you find it—and it may be easier than you think. Your inquiry entails no obligation whatever. The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

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Pin Wire	Hook & Eye Wire	Nail Wire
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Chain Wire	Brake Lining Wire	Tie Wire
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MATERIALS

Copper	Brass	*Hitenso Cadmium Bronze
Chromium Copper	Zinc	*Calsun Bronze
Deoxidized Copper	Phosphor Bronze	Ambraloy
Silver Bearing Copper	Nickel Silver	Special Copper Alloys
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Round	Half-oval	Square
Half-round	Flat	Hexagonal
Oval	Keystone	Octagonal
	Irregular Shapes on Order	

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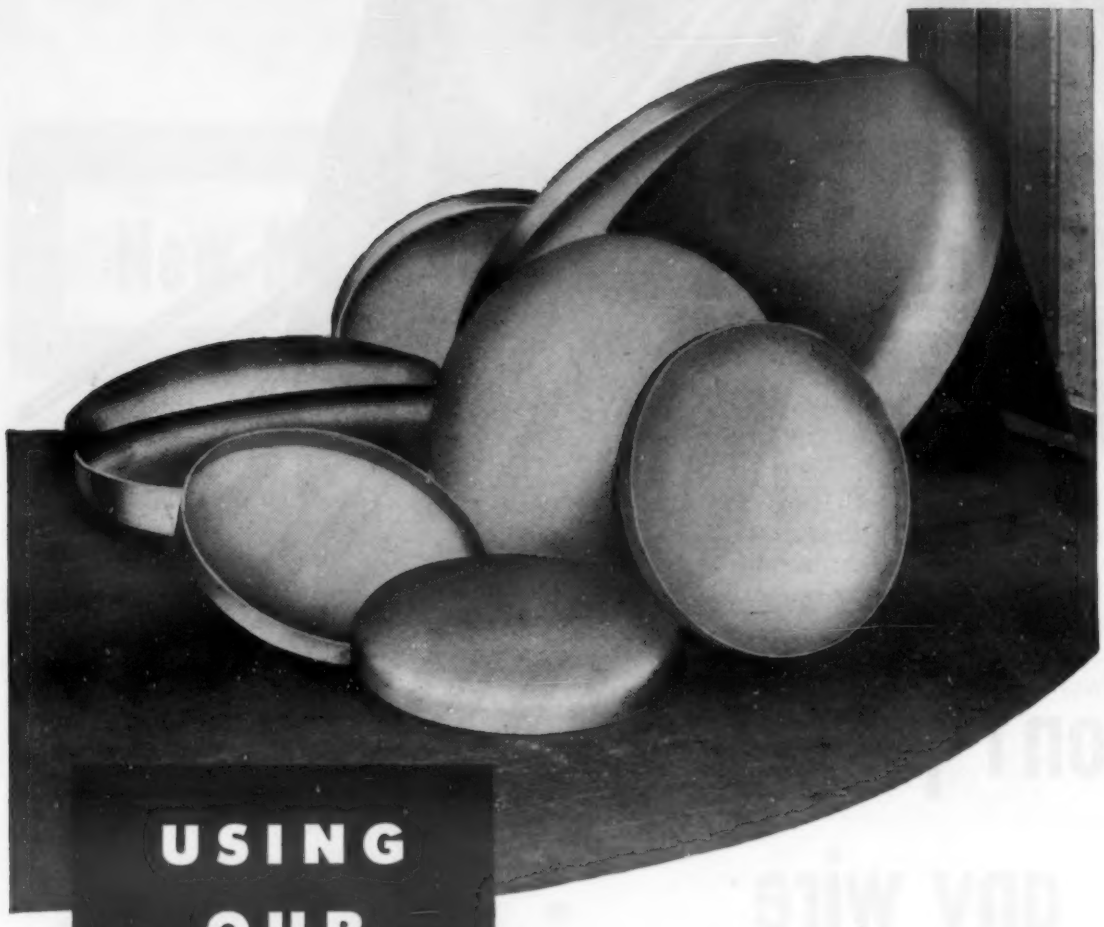
SUITABLE FOR THESE FABRICATING OPERATIONS

Redrawing	Riveting	Braiding
Cold Heading	Machining	Spinning
Hot Heading	Flat rolling	Weaving
Extruding	Edgewise winding	



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thick. Porosity is controlled to provide a wide variety of filtering or fluid flow characteristics.

The porous metal sheets are being used in a number of aircraft applications including (1) wing surfaces for control of boundary-layer effect of rapid air flow, (2) wind tunnel linings where air passage over surfaces can be controlled by applying either a positive or negative air pressure through the porous lining, and (3) surfaces through which de-icing fluid is pumped. In addition, experiments are being conducted in industry on sweat-cooling of surfaces by pumping liquids through porous bronze or nickel.

Low-Alloy Welded Pipe

The availability of continuous-welded pipe fabricated from Yoloy, a nickel-copper low-alloy steel, has been announced by *Youngstown Sheet & Tube Co.*, Youngstown 1, Ohio.

Chief advantages claimed for Yoloy con-

Yoloy continuous-weld pipe can be easily identified.

tinuous-weld pipe are: (1) easy to weld, (2) bends and fabricates easily, (3) high tensile strength, (4) abrasion resistant, (5) high resistance to shock and vibration, and (6) high corrosion resistance. Yoloy is estimated to have 4 to 6 times the corrosion resistance of regular carbon steels.

Approximate composition of Yoloy is 0.08 carbon, 2.0 nickel and 1.0% copper. Previously it has been available in seamless pipe, sheets, plates and structural members.

Glass Fiber Insulation

A braided Fiberglas tubing and sleeving claimed to have high physical and dielectric properties has been announced by *Bentley, Harris Manufacturing Co.*, Conshohocken, Pa. Named BH 649, this product is available at a price comparable to ordinary cotton-base or rayon-base insulations.

BH 649 withstands knotting, twisting and direct flame without breakdown and with little or no loss of dielectric strength

SEALED FOR LIFE

WITH A PRESSURE-TIGHT

MEEHANITE® CASTING

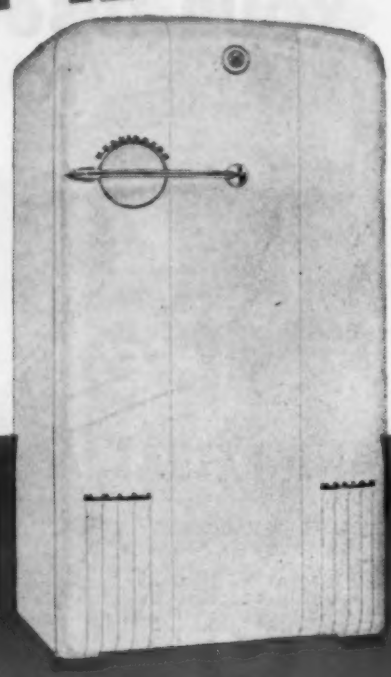

Figure 1—The famous "Kelvinator" electric refrigerator. A Masterpiece model with full-length door design.

A major design improvement in the refrigerator-compressor industry has been the development of the permanently sealed-type compressor. Nash-Kelvinator Corporation, Detroit, Michigan produces a series of home and industrial refrigerator units utilizing this principle which provides the maximum in quiet, efficient and trouble-free service life.

At the time of the original change-over the main compressor body was designed as a Meehanite casting in order to obtain the maximum in pressure tightness, machinability, all-round casting quality and uniformity.

The Meehanite compressor body illustrated (Fig. 2) is subjected to 73 machining operations, one of which is diamond boring. Even a pinpoint defect under these conditions would cause leaking. Connecting rod bearing surfaces on this casting are held to .0005" tolerance. So close and accurate must be the dimensions that many measurements are made electrically.

All castings are, of course, pressure tested and the finished unit is forced under a 5½ ton pressure into a sealed dome.

Figure 2 — The Meehanite compressor body providing maximum properties and pressure tightness to Nash-Kelvinator compressor units.

Figure 3—Nash-Kelvinator Corporation "sealed for life" refrigerator compressor unit.

Take Your Casting Problems to a MEEHANITE Foundry!

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The American Laundry Machinery Co. — Rochester, New York
Atlas Foundry Co. — Detroit, Michigan
Banner Iron Works — St. Louis, Missouri
Barnett Foundry & Machine Co. — Irvington, New Jersey
E. W. Bliss Co. — Hastings, Mich. and Toledo, O.
Builders Iron Foundry Inc. — Providence, Rhode Island
Continental Gin Co. — Birmingham, Alabama
The Cooper-Bessemer Corp. — Mt. Vernon, Ohio and Grove City, Pa.
Farrel-Birmingham Co., Inc. — Ansonia, Connecticut
Florence Pipe Foundry & Machine Co. — Florence, New Jersey
Fulton Foundry & Machine Co., Inc. — Cleveland, Ohio
General Foundry & Manufacturing Co. — Flint, Michigan
Greenlee Foundry Co. — Chicago, Illinois
The Hamilton Foundry & Machine Co. — Hamilton, Ohio
Johnstone Foundries, Inc. — Grove City, Pennsylvania
Kanawha Manufacturing Co. — Charleston, West Virginia
Koehring Co. — Milwaukee, Wisconsin
Lincoln Foundry Corp. — Los Angeles, California
E. Long Ltd. — Orillia, Ontario
Otis Elevator Co., Ltd. — Hamilton, Ontario
The Henry Perkins Co. — Bridgewater, Massachusetts
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The Stearns-Roger Manufacturing Co. — Denver, Colorado
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UNITED STATES STEEL

New Materials and Equipment

after rough handling. It also cuts clean and makes wire threading easy because there are no frayed ends.

With this material, potting temperatures of 450 F up to 60 min. can be used. It can be exposed to 220 F for 96 hr. with no physical change or loss of dielectric strength. Its resistance is 50,000 megohms when dry, 10,000 when wet.

The new insulation is made in Grade A-1 and Grade B-1 tubing, and Grade C-1 and Grade C-2 sleeving in standard black and yellow, as well as red, green and brown. Sizes range from No. 20 to ⅜ in. inclusive.

●

Coatings & Finishes

Reproducible Hammer Finish

A method of applying a consistently reproducible hammer finish for metals has been worked out by *Resinous Products Div.* of *Rohm & Haas Co.*, 224 W. Washington Sq., Philadelphia 5, Pa. The method utilizes a one-coat spray containing Duraplex C-55X and Parlon.

For best results the coating should be sprayed at a viscosity of 62 sec. on a No. 4 Ford cup, using a No. 30 DeVilbiss air cap and a pressure of 15 psi. through the feed cup. Recommended atomizing pressure through the spray gun is 50 psi. Tinting pastes, added in extremely small amounts, accentuate the hammer effect. This finish dries tack-free in 60 to 90 min., and shows a Sward rocker hardness of 26 to 30 after a 16-hr. dry.

The formulation is as follows:

Material	*Pounds*
Parlon, 10 Centipoise (22.1% solids in High Flash Naphtha)	60.5
Duraplex C-55X (70% Solids)	37.8
Alcoa Paste No. 1594	2.0
Butanol	2.0
6% Cobalt Naphthanate	0.24

Influence of variables on the hammer pattern was determined as follows:

1. Increasing pressure through spray gun increases size of pattern.
2. Raising pressure on feed cup gives larger pattern and deposits heavier film.
3. The more the enamel is atomized as it leaves spray gun, the less it tends to form a hammered texture (probably most important factor in obtaining uniformity).
4. Addition of butanol improves hammer pattern.

ESNA *Self-Locking* FASTENERS

Anchor Nuts For Blind Mounting
Self-Aligning Floating Basket Nuts
Deep or U-Bolt Nuts
Hex Nuts
Press Fit Spline Nuts
Pressure Sealing, Decorative Nylon Cap Nuts
Industrial Hy-Temp Nut Self-Locking to 550°F
Clinch Type Sheet Metal Nuts
High Tensile Nuts
Gang Channel

3011 ways to solve your Fastening Problems

When fastening problems come up, are you ready with an immediate answer? Or, do you find that many of your problems are major design jobs?

If fastening presents any problem at all, Elastic Stop Nuts can supply the answer fast. In stock, ready for delivery to you when you say the word, ESNA has 453 off-the-shelf answers to your problems. Tooled for production, ESNA has 2558 more.

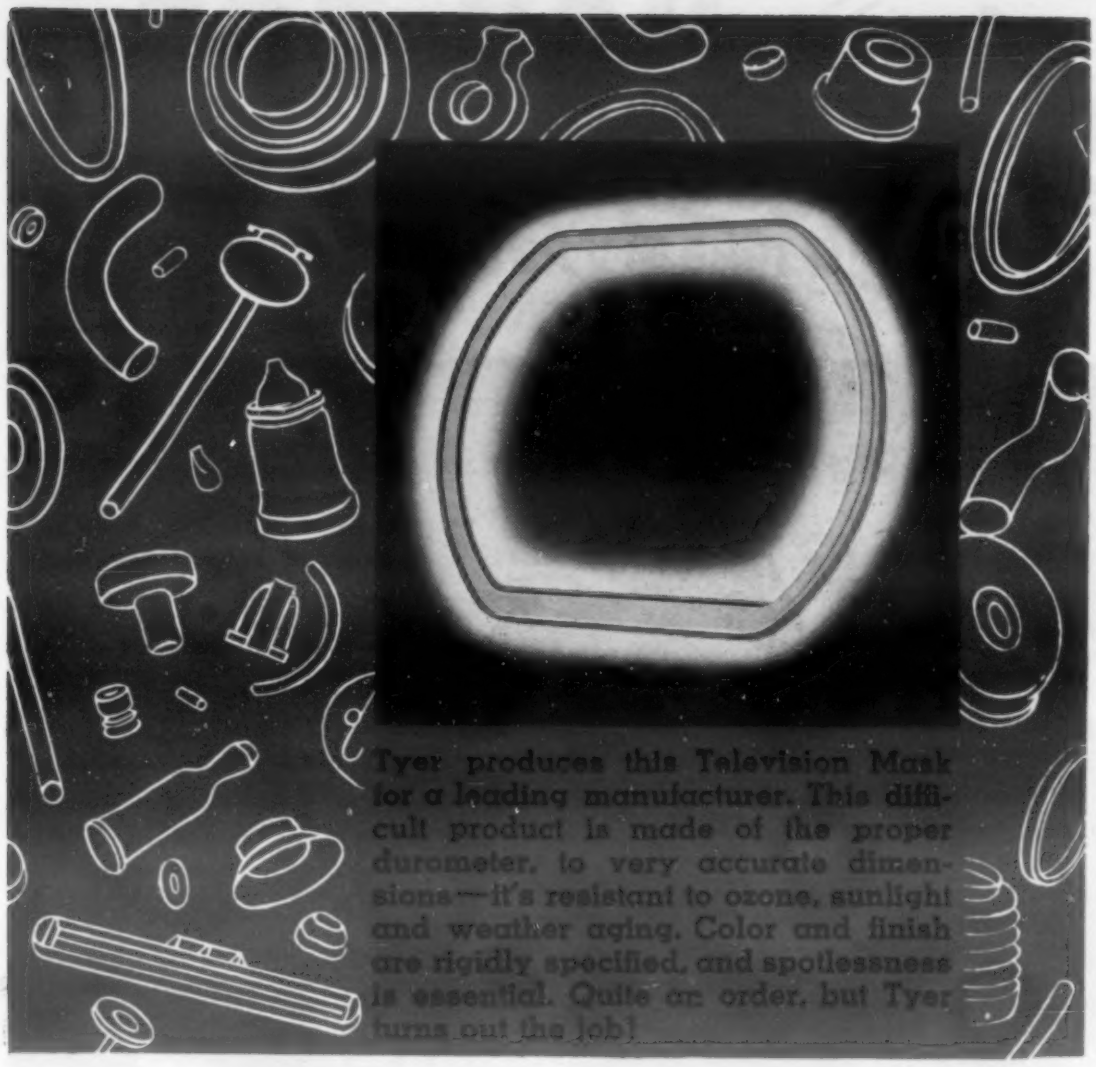
Yes, 3011 types and sizes of Elastic Stop Nuts cover just about every fastening job you run into. And the self-locking action of the Red Elastic Collar is your guarantee of performance. For instance, when you want to pre-stress a bolt to assure proper load distribution; or if you must "set" and maintain an exact spring-loaded adjustment; the torque provided by the grip of the Red Elastic Collar on bolt threads, will do the job. When you've got to have a fastener with a locking hold that can't be shaken loose by the toughest mechanical or operating vibration, the answer is an Elastic Stop Nut. If you need a fastener that will protect internal bolt threads against corrosion and assure easier repair jobs . . . the moisture seal and guarantee of reusability provided by the Red Elastic Collar means that your fastener is an Elastic Stop Nut.

Problems like yours are solved at ESNA day after day—and have been since 1927. In the railroad industry, in the oil fields, in automobiles, aircraft, and construction projects, reusable, precision-setting Elastic Stop Nuts are doing the kind of fastening job you're looking for.

If your problem is a common one, ESNA will supply one of the 3011 types of Elastic Stop Nuts immediately. If you need a special design, ESNA will make quick work of your problem by handling both design and manufacture. Why not get ready to handle that next fastening problem now? Send details of your problem, or write asking for a call from an ESNA engineer. For the new ESNA catalog, write Elastic Stop Nut Corporation of America, Union, N. J.

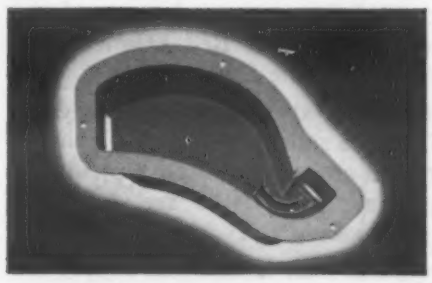
ESNA TRADE MARK

ELASTIC STOP NUTS



Tyer produces this Television Mask for a leading manufacturer. This difficult product is made of the proper durometer, to very accurate dimensions—it's resistant to ozone, sunlight and weather aging. Color and finish are rigidly specified, and spotlessness is essential. Quite an order, but Tyer turns out the job!

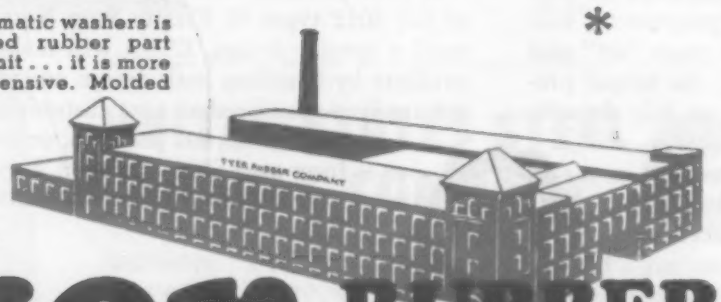
For 92 years Tyer has been doing remarkable things with rubber. Tyer originated WHITE RUBBER and ELASTIC WEBBING. Tyer's war products ranged from giant pontons to tiny earplugs made to a tolerance of one thousandth of an inch. Today Tyer leads in SERVICE to INDUSTRY. Many of the country's finest products have vital rubber parts made by Tyer. These famous manufacturers know that Tyer does unusual things with rubber.



This soap dish for automatic washers is an intricately-fashioned rubber part that replaces a metal unit . . . it is more efficient and less expensive. Molded by Tyer.

If there is a rubber part in your product (old, new or proposed) Tyer technicians will give you the utmost cooperation in putting all Tyer's 92 years of experience at your service. Ask the Tyer representative. Write to us in Andover or to the nearest branch.

*



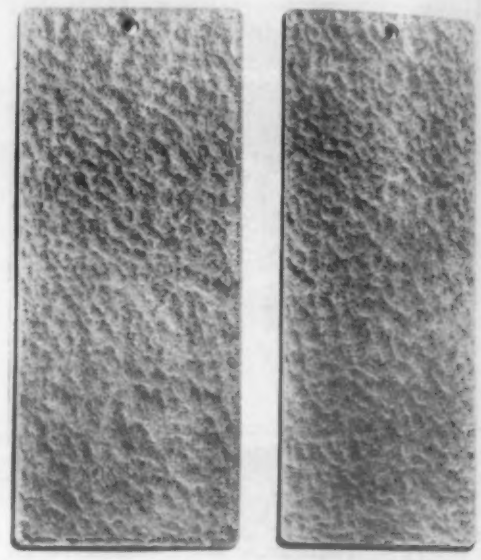
Tyer RUBBER COMPANY

* **ANDOVER, MASSACHUSETTS**

159 Duane St., NEW YORK 189 W. Madison St., CHICAGO 3-252 Gen. Motors Bldg., DETROIT

New Materials and Equipment

5. Optimum hammer effect is obtained with a one-mil dry film. Heavier films tend to reduce texture.



These panels, sprayed two months apart by different operators, demonstrate the reproducibility of the Rohm & Haas hammer finish.

6. The longer the set time used, the larger will be the type of texture formed, as the hammer effect is produced before the finish sets.

Solution-Applied Coating

A new Geon resin, designated 200 X 20, which can be used to produce adherent films on a variety of surfaces including aluminum, copper, lead, tin plate and steel, has been announced by *B. F. Goodrich Chemical Co.*, 324 Rose Bldg., Cleveland 15, Ohio. The product is a vinyl-vinylidene chloride copolymer unique among commercial vinyl resins because of its solubility directly in toluene, xylene and high aromatic naphthas.

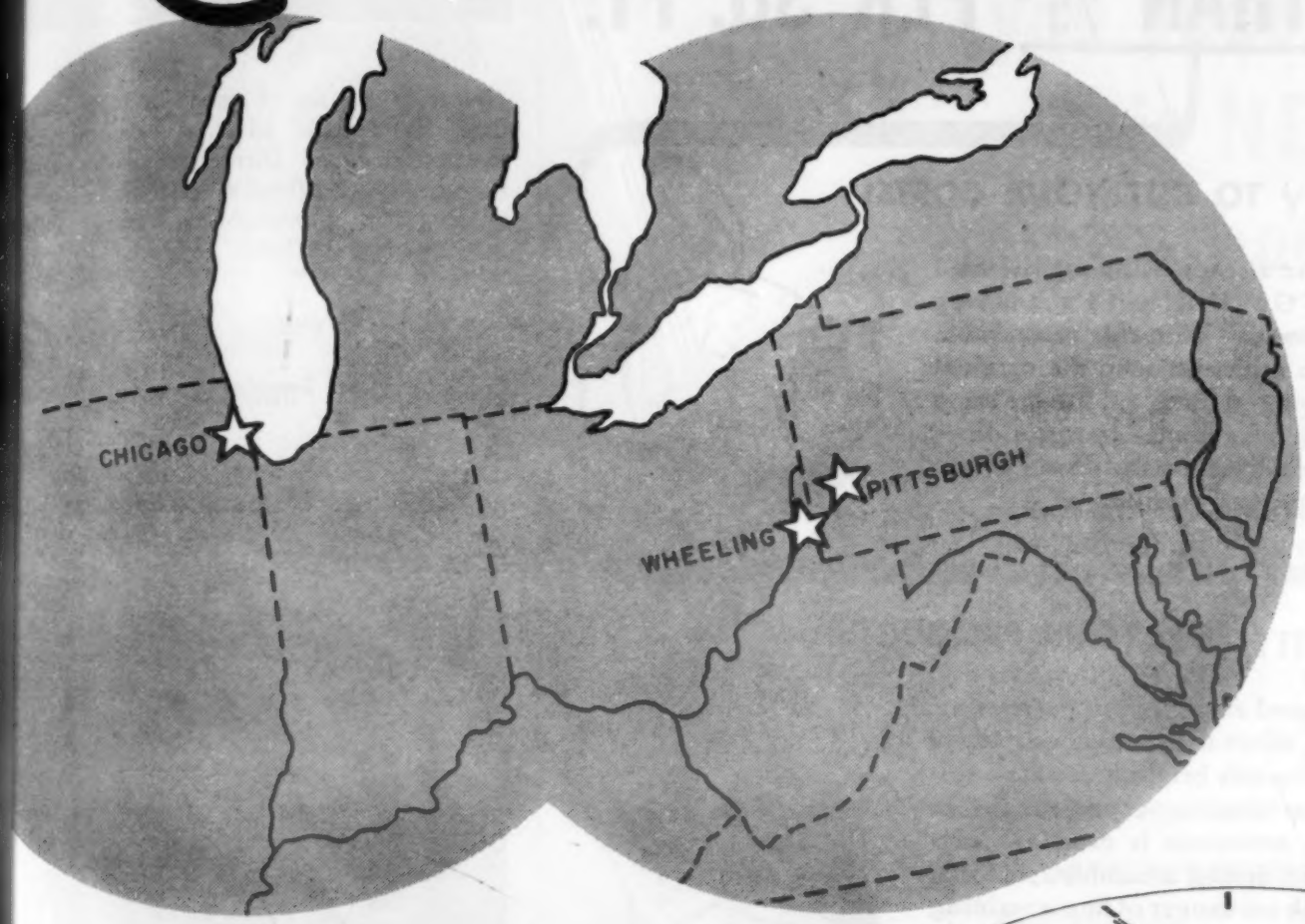
Solutions ranging up to 50% total solids content can be prepared readily with Geon 200 X 20 by addition of the resin slowly to a solvent at ambient temperatures with rapid mechanical agitation. Stability is such that high solids solutions can be cooled to 32 F and, upon warming to room temperature, recover original viscosities without gelling.

The resin solutions can be brushed, sprayed, roller coated, or in the higher viscosity ranges, knife or bar coated. Films cast from Geon 200 X 20 are said to have sufficient flexibility for most applications for which the resin is intended; it can be plasticized where additional flexibility is required.

At present, most applications of Geon

LOCATION MEANS SAVINGS WITH

Continental STEEL CASTINGS



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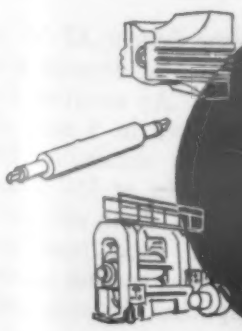
IS CLOSE TO HEAVY INDUSTRY

With three large and complete steel foundries, Continental is ideally located to serve the heart of the North Central and Midwestern industrial areas.

If your plant lies within the shaded areas on the map above, you are within easy and inexpensive shipping distance of any one of the three large Continental foundries. Excellent rail, water, truck and air transportation from this area also puts all of industrial America in the "Continental Zone" of service.

When you consider the location and shipping facilities of your steel castings source . . . know that Continental is ideally situated to serve you!



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FOUNDRY & MACHINE CO.
EAST CHICAGO, IND. • PITTSBURGH, PA.
Plants at: E. Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.

Carbon and Alloy Steel Castings from 20 to 250,000 pounds

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Complete Rolling Mills and Auxiliary Equipment

•

Iron, Alloy Iron and Steel Rolls for all industries

NEW LUSTER-ON UTILITY-15 GIVES CHROME-LIKE BRILLIANCE FOR LESS THAN 1/5¢ PER SQ. FT.

NEW ECONOMY TO CUT YOUR COSTS!

To every manufacturer already using a passivated zinc finish, Luster-On Utility-15's amazing economy is the big news. With this remarkable new product, you can replenish with the original solution . . . dilute up to 10 times . . . use the same solution for manual or automatic operation — features never before possible with a zinc bright dip. Savings run 50% and even more!

NEW SALEABILITY FOR YOUR PRODUCTS!

If you use electro-plated zinc without passivating, Luster-On Utility-15 offers the tremendous added sales appeal of permanently bright finish at almost negligible cost — less than 1/5¢ per sq. ft. In addition, corrosion resistance is excellent, permitting free handling during assembly, packing, display and use — with no danger of finger staining or discoloration. Where chrome-like brilliance is not required, maximum corrosion protection can be secured with a single dip.

NEW RELIABILITY AND EASE OF APPLICATION!

For companies now using Cadmium or Nickel, Luster-On Utility-15 provides the great economy and speed of passivated zinc, plus sensational new simplicity and reliability of application. Composed of 95% inorganic materials, Luster-On Utility-15 is highly stable. With it, work can be handled on racks or by bulk dipping, with freedom from iridescence and exceptional uniformity. No noxious fumes . . . requires no exhaust.

Send for full details today on . . .

New Luster-on® Utility-15

In attendance at the Boston AES Convention

THE Chemical CORPORATION

54 Waltham Ave., Springfield 9, Mass.

THE CHEMICAL CORPORATION
54 Waltham Ave., Springfield, Mass.

Please send me full particulars about Luster-On Utility-15 for zinc-plated surfaces. I am (am not) sending sample for free dip. No obligation, of course.

Name.....

Firm.....

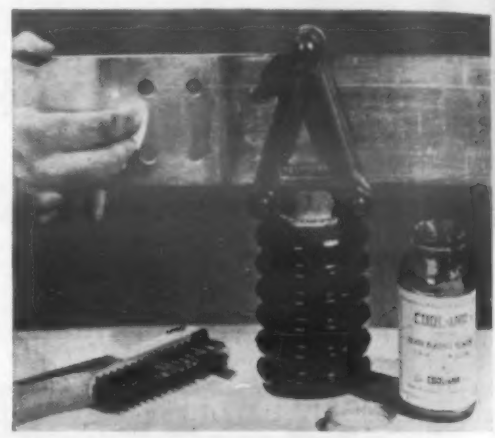
Address .....

New Materials and Equipment

200 X 20 consist of paper or fabric coatings. Its principal advantages can be summarized as good chemical and water resistance, good adhesion when baked adequately, non-inflammability, and solubility in cheap hydrocarbons.

Silver Plating Powder

A silver plating powder which can be used to deposit an adherent coat of silver on high-amperage electrical connections has been developed by *Cool-Amp Co.*, 8603 S. W. 17th Ave., Portland, Ore. The plate



A pound of Cool-Amp powder will silver plate about 6000 sq. in. of metal surface.

is intended to provide cool, maximum conductivity for copper, brass or bronze contracts and thereby reduce power losses caused by overheating.

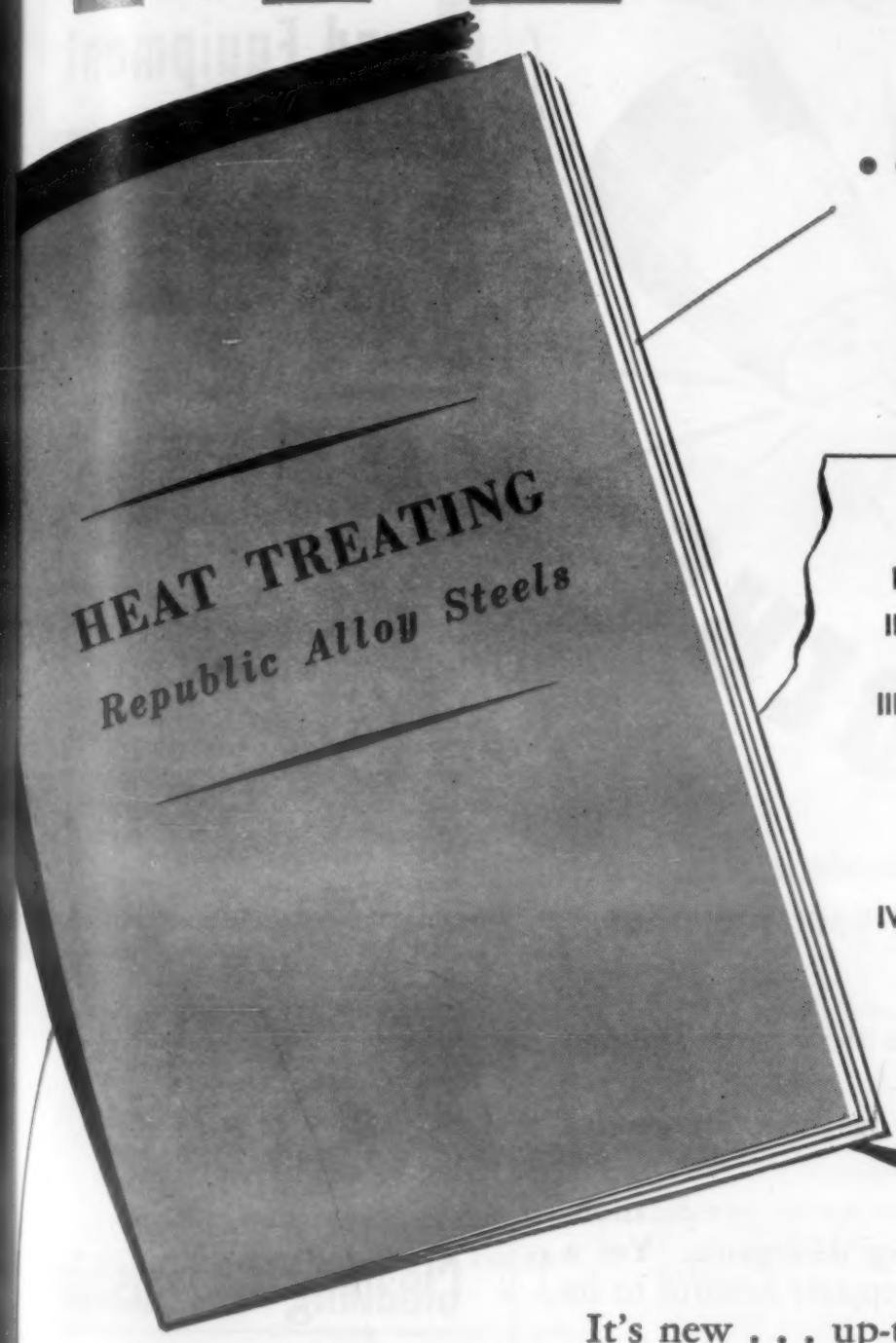
The only equipment required is a sharp steel wire brush or abrasive cloth, clean rag and water.

Metal Primer

United Chromium, Inc., 51 E. 42 St., New York 17, has recently announced a new metal primer which is claimed to provide good adhesion on hard-to-coat magnesium and aluminum without chemical or electro-chemical pretreatment. Other metals to which it is applicable are stainless and carbon steel, galvanized metals, Monel, tin, copper and brass.

Named Unichrome Primer AP-10, it can be applied by spraying or dipping and can be air-dried or baked. An air-dried film of AP-10 becomes dust-free in 5 min. For a coating with optimum durability, baking schedules between 5 min. at 350 F and 20 min. at 300 F are used. Both air-dried and baked coatings have good resistance to moisture, and the baked coating resists solvents, alcohols, naphthas, ketones, coal tar

If you use Alloy Steels...



...you should have this NEW helpful booklet!

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II Transformation of Austenite Shown Graphically (Isothermal Transformation Diagrams)

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Hardening	Cyaniding
Martempering	Flame Hardening
Carburizing	Induction Hardening

IV Mechanical Properties of Alloy Steels

DATA & REFERENCE CHARTS

Critical Points	Carburizing Depths
Ms Calculation	Nitriding Depths

Mechanical Properties

It's new . . . up-to-the-minute . . . 54 pages of valuable heat treating data that belongs on the desk of every alloy steel user.

Republic—world's largest producer of alloy and stainless steels—offers you this useful booklet without cost or obligation in any way.

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Please send me a copy of your new booklet *Heat Treating Republic Alloy Steels.*

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ITS LIFETIME OF HARD KNOCKS

puts a materials testing laboratory right at your fingertips.

A bowling ball is made to specifications that are *tough!* Tougher than most machine parts.

It takes hard knocks with a bounce, and at the same time retains its perfect balance and smooth finish.

In the heat of a game it is subjected to corrosive perspiration, floor wax, water, chalk, and even cleaning detergents. Yet a genuine Ace Hard Rubber Bowling Ball remains faithful to its owner for years.

That's because it's made of tough Ace Hard Rubber, with tensile strength of 9,000 psi, flexural strength of 11,500 psi. And it's the same impervious material that's used for piping acids.

It's a good example of fabricating, too, with amazingly close tolerances on weight and diameter. It starts as a molding. Then it's ground and polished to give that smooth, satiny feel. Finally the finger holes are machine cut.

Yes, it shows some of the reasons why Ace Hard Rubber is preferred for thousands of parts for machines, appliances, automobiles, furniture, etc. Chances are it's best for some of *your* parts, too. Why not give it a whirl?

Send for free 60-page Ace Handbook —a gold mine of helpful data

ACE AMERICAN HARD RUBBER COMPANY

Since 1851

HARD RUBBER and PLASTICS

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New Materials and Equipment

derivatives, and solutions of many metallic salts.

AP-10 can be covered with lacquers, synthetics or baking enamels. A number of decorative and chemical-resisting coating systems using AP-10 and various finishes, including vinyls, phenolics and alkyds, have been developed by this company. Originally known as Aviation Primer AP-10, the primer was developed by Princeton Paint Laboratories.

Primer for Corroded Steel

An anti-corrosive primer for corroded iron and steel has been developed by *Brooklyn Varnish Manufacturing Co.,* 50 Jay St., Brooklyn 1, N. Y. Called Tuf-on-Rust, the primer can be applied over rusted surfaces where complete rust removal is not possible.

Tuf-on-Rust dries in about 4 hr. for recoating, thus avoiding the problem of extensive dirt collection. It can be applied by brush or spray. For maximum weather resistance, it should be followed by a durable topcoat.

Cleaning & Finishing

Pre-Paint Metal Cleaner

An acid-type metal-cleaning material which removes oil and rust and prepares the metal for painting has been announced by *Oakite Products, Inc.,* 22 Thames St., New York 6. It is called Oakite Compound No. 33.

The solvent and detergent properties of No. 33 are reported to be effective in removing stamping and forming oils, rust preventives, carbon smuts, soldering and welding fluxes, identification inks, and similar soils. It also contains acid ingredients and accelerating agents which act to remove rust, heat scale, tarnish and other oxides. Finally, Oakite No. 33 microscopically etches steel and cast iron, and converts the surface layer of metal into a thin film of insoluble phosphates. It has similar action on aluminum sheet and castings. The result is that subsequent paint adhesion is much improved.

Oakite Compound No. 33 is an amber-colored, syrupy liquid having an aromatic odor. It has a bulk density of 11.3 lb. per gal. Its flash point is 240 F, and it will not

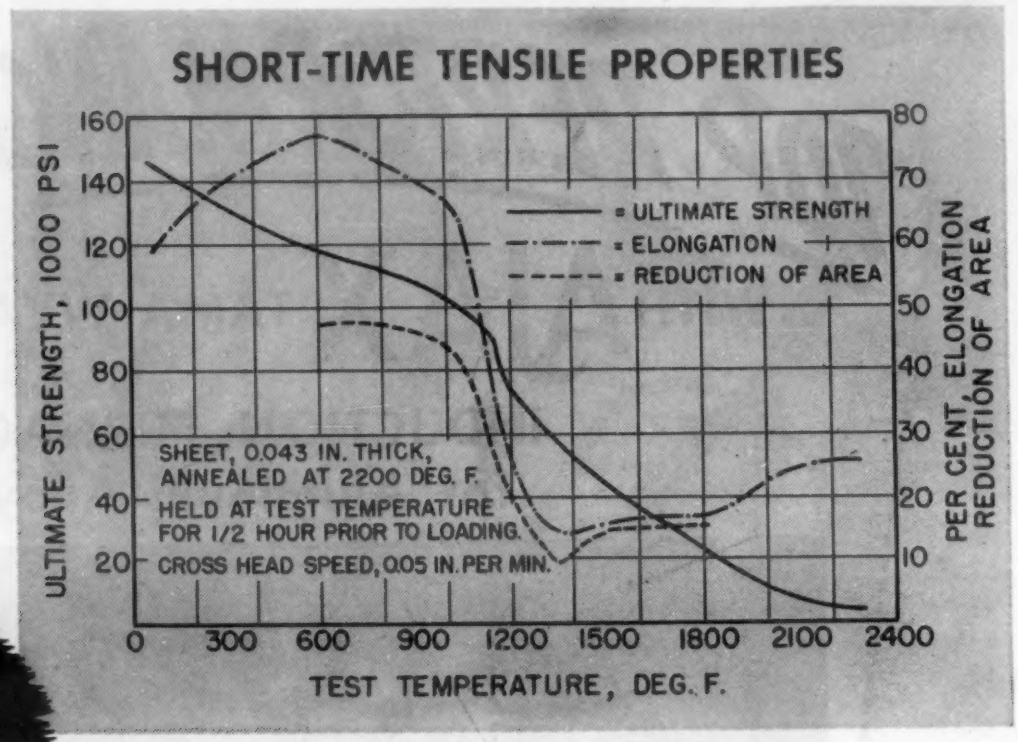
HAYNES
TRADE-MARK
Alloy No. 25

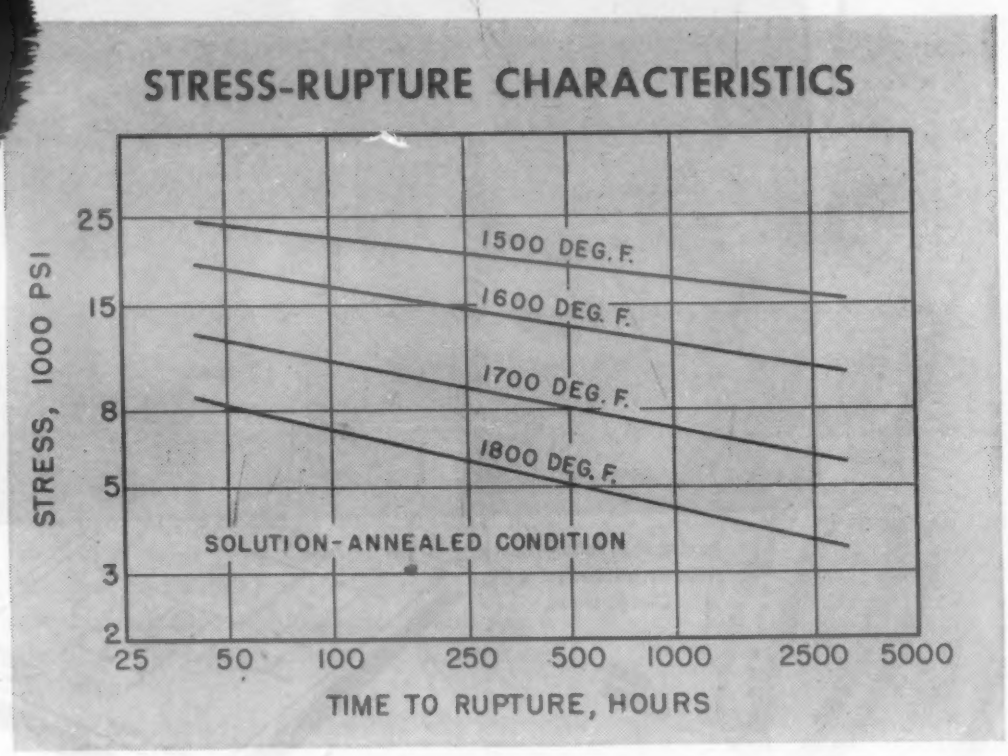
STRONG up to 1800°F. without aging

DUCTILE at room temperature

HAYNES alloy No. 25 is a new wrought high-temperature alloy that has exceptional mechanical properties at temperatures up to 1800 deg. F.—*in the fully annealed condition without subsequent aging*. Yet this alloy is *easy to fabricate* because it has excellent ductility at room temperature. This combination of properties makes HAYNES alloy No. 25 an ideal material for the construction of highly stressed parts that must operate at elevated temperatures.

This latest addition to the series of HAYNES high-temperature alloys was developed as a wrought material to withstand a minimum stress of 6,000 lb. per sq. in. for 100 hours at 1800 deg. F. It is available as sheet, plate, bar stock, and tubing.


SHORT-TIME TENSILE PROPERTIES
ULTIMATE STRENGTH, 1000 PSI
PER CENT, ELONGATION REDUCTION OF AREA
= ULTIMATE STRENGTH
= ELONGATION
= REDUCTION OF AREA
SHEET, 0.043 IN. THICK, ANNEALED AT 2200 DEG. F.
HELD AT TEST TEMPERATURE FOR 1/2 HOUR PRIOR TO LOADING.
CROSS HEAD SPEED, 0.05 IN. PER MIN.
TEST TEMPERATURE, DEG. F.



Consult our nearest office for engineering data and assistance in solving your high-temperature problems with HAYNES alloy No. 25. Physical and mechanical properties of the other 9 HAYNES high-temperature alloys are given in tabular and graphic form in the booklet, "HAYNES Alloys for High-Temperature Service." Data on short-time tensile properties, stress-rupture, creep test, endurance properties, and fabrication procedures are included. Write to Haynes Stellite Division, UCC, 731 S. Lindsay St., Kokomo, Ind.

Haynes Stellite Division
Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago — Cleveland — Detroit — Houston
Los Angeles — New York — San Francisco — Tulsa

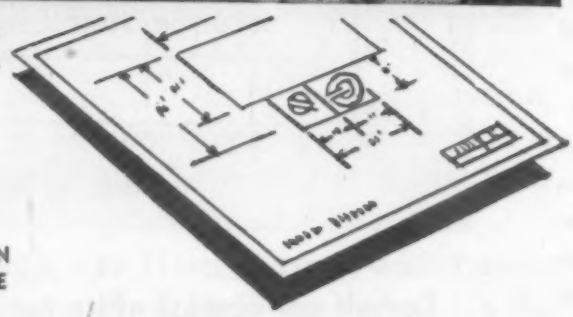
HAYNES
TRADE-MARK
alloys

The trade-mark "Haynes" distinguishes products of Union Carbide and Carbon Corporation.

TOP PERFORMANCE WITH AJAX TAMA-WYATT

INDUCTION FURNACES for Aluminum Alloys

Ajax Induction Holding Furnace at Mid-Western Die Casting Co., Chicago, Illinois.



BETTER PRODUCTION THROUGH TOP PERFORMANCE IS THE AJAX RECORD

Ajax-Tama-Wyatt induction furnaces are used in the United States and abroad for melting and holding aluminum alloys in die casting, permanent mold, and sand foundries.

No flux or mechanical stirring is necessary. The metal is in constant gentle circulation assuring complete blending of alloys, and a uniform temperature throughout the metal.

Electric energy costs less than fuel and avoids danger of overheating. Completely automatic temperature controls hold metal to within 5°F., at the lowest possible temperature for perfect casting. With an Ajax the yield for perfect castings is exceptionally high.

There are no fumes and operation is practically noiseless. Shops are cooler, more comfortable — manpower efficiency is increased. Shop space is increased, for an Ajax Holding Furnace takes an average of 30 to 40 percent less floor space than any other furnace.

The Ajax companies have been pioneers in induction melting of metals since the first World War. To date they have installed more than 400,000 KW. of furnace capacity in the United States alone. This is the background of experience behind every Ajax installation.

AJAX ENGINEERING CORPORATION • Trenton 7, New Jersey

AJAX TAMA-WYATT INDUCTION MELTING FURNACE

Associate Companies: AJAX METAL COMPANY, Non-Ferrous Ingot Metals and Alloys for Foundry Use
AJAX ELECTROTHERMIC CORP., Ajax-Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax-Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax-Wyatt Induction Furnaces for Melting

New Materials and Equipment

burn when a flame is applied directly to i surface.

For tank immersion cleaning, No. 33 c be diluted with water at from 10 to 25 by volume. The solution can also be heate to 140 F for increased detergency. Tank should be made of stabilized or low-carbo stainless steel, or of wood, glass or ceramic The compound is also suitable for hand swabbing of parts.

Bench Blast Cleaning Machine

A portable, bench blast-cleaning machin for small parts, such as automobile pistons dies, tools, castings, etc., is being offered b the *W. W. Sly Manufacturing Co.*, 470 Train Ave., Cleveland 2, Ohio. This abrasiv blast cleaner will operate on compresse

The operator of this Sly blast cabinet loads parts through top hinged cover and observes work through window in cover.

air supplied by a standard 5-hp., 2-stage garage compressor.

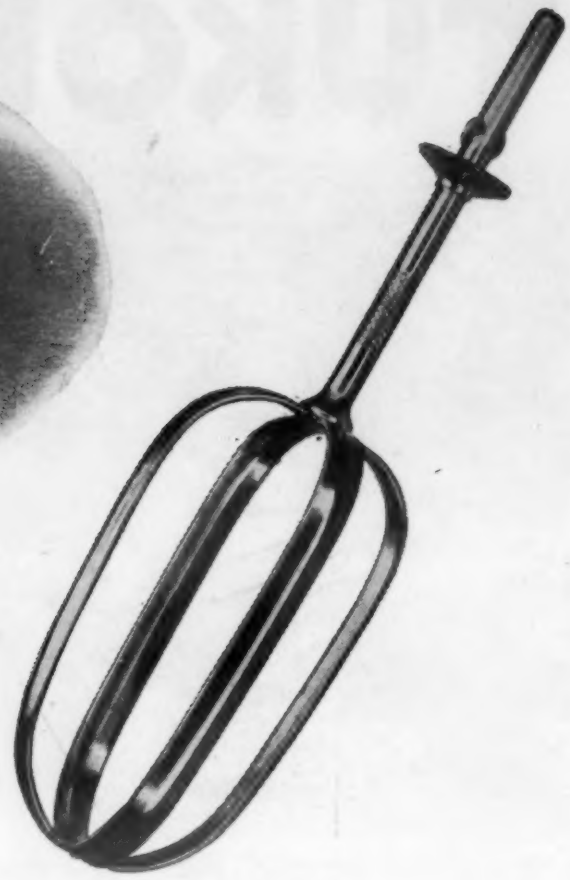
A ventilating fan draws off the dust, which is retained in a removable filter bag. Good vision during blasting is provided by a side-mounted light.

Boiler for Steam Spray-Guns

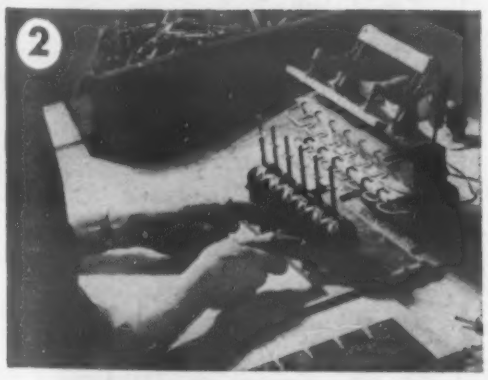
In anticipation of increased use of steam instead of compressed air for spray painting, *Livingstone Engineering Co.*, 100 Grove St., Worcester 5, Mass., has introduced the Speedylectric SP500, an all-electric steam power plant complete with built-in 100-psi. boiler.

The boiler is available in a range of capacities from 1 to 10 spray-guns or larger.

ELECTRIC MIXER BLADES MADE BETTER WITH EASY-FLO



The new G.E. 3-bladed food mixer has a blade construction that is 100% sanitary. In place of the traditional hard-to-clean center stem design, the blade is an all-EASY-FLO brazed assembly that offers not the tiniest crevice in which food particles can lodge, and at the same time, is exceptionally strong. With the set-up and procedure shown below, the Hunter Spring Co., Lansdale, Pa. turns out 20,000 assemblies a week for G.E., totaling 60,000 EASY-FLO joints.



HERE'S THE FAST PRODUCTION SET-UP

1. Small square of EASY-FLO shim stock is placed on top of criss-crossed blades in a fixture which accurately locates alloy and parts. Spot welder does the brazing.

2. Stems and blades, with EASY-FLO square between, are assembled in a fixture and brazed 6 at a time in coil of induction heater. EASY-FLO wire ring is placed around stem above dough guard and again the 6 are brazed at one time, completing the assembly.

3. Shows where EASY-FLO is preplaced.

4. When blades are twisted to destruction the stem breaks—the EASY-FLO joints hold.

A QUICK WAY TO FIND OUT WHAT *EASY-FLO* WILL DO

FOR YOU—Write or call and ask for a field service engineer. He'll demonstrate EASY-FLO and discuss its application to your metal joining work—all with no obligation to you of any kind.

BULLETINS 12-A, 15 AND 17 will give you EASY-FLO facts in print. Write for copies today.

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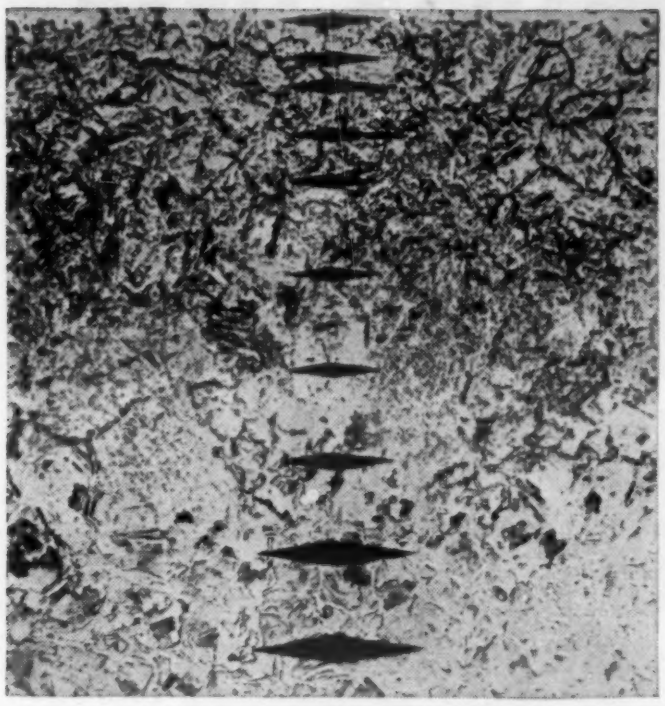
TUKON



X 100—*TUKON Test on SAE 1020 Steel—Carbonitrided. Load 500 Grams.*

3 MODELS

TUKON TESTER *for* MICROHARDNESS TESTING

FOR EVERY KIND OF MICRO-INDENTATION HARDNESS TESTING

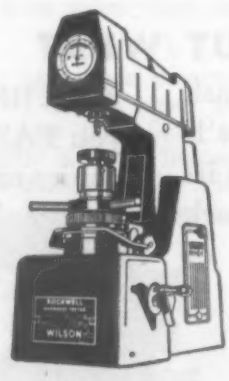
Send for Bulletin DH-114 which contains detailed information about TUKON Hardness Testers. We will also include a copy of our booklet DH-7, which gives the experience of several users of TUKON Testers in different fields.

● The TUKON Tester may be used for testing the constituents of an alloy, thin material, small specimens, small diameter wire and for many kinds of research work—the full range of micro and macro hardness testing. All models may be used with either Knoop or 136° Diamond Pyramid Indenter. Applied loads: Model MO—1 to 1000 grams; Model FB—10 to 3600 grams; Model LR—10 to 50,000 grams.

"ROCKWELL" HARDNESS TESTER

● "ROCKWELL" Hardness Testers and "ROCKWELL" Superficial Hardness Testers were developed and are made only by Wilson for laboratory, toolroom or production line testing.

Write us about any problem you may have involving hardness testing. Our factory-trained Field Service Engineers will be glad to work with you.



WILSON MECHANICAL INSTRUMENT CO., INC.

AN ASSOCIATE COMPANY OF AMERICAN CHAIN & CABLE COMPANY, INC.

230-E PARK AVENUE, NEW YORK 17, N. Y.

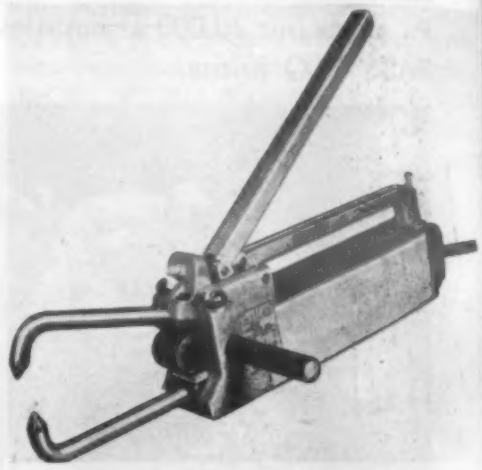
ACCO

New Materials and Equipment

Welding

Portable Spot Welder

A portable spot welder, Model LMSW-52, which will handle combined thicknesses of mild or stainless steel up to 3/16 in., has been introduced by *Miller Electric Manufacturing Co.*, Appleton, Wis. The



The Miller Model LMSW-52 portable spot welder is capable of higher output than the earlier model.

new unit, for 220-v. lines only, has about twice the output of this company's previously announced MSW model.

The welder incorporates the Miller pressure tong lever, which enables the user to obtain a tight "spot" even where fit-up is poor on the lighter gages of metal. The unit weighs 31 lb.

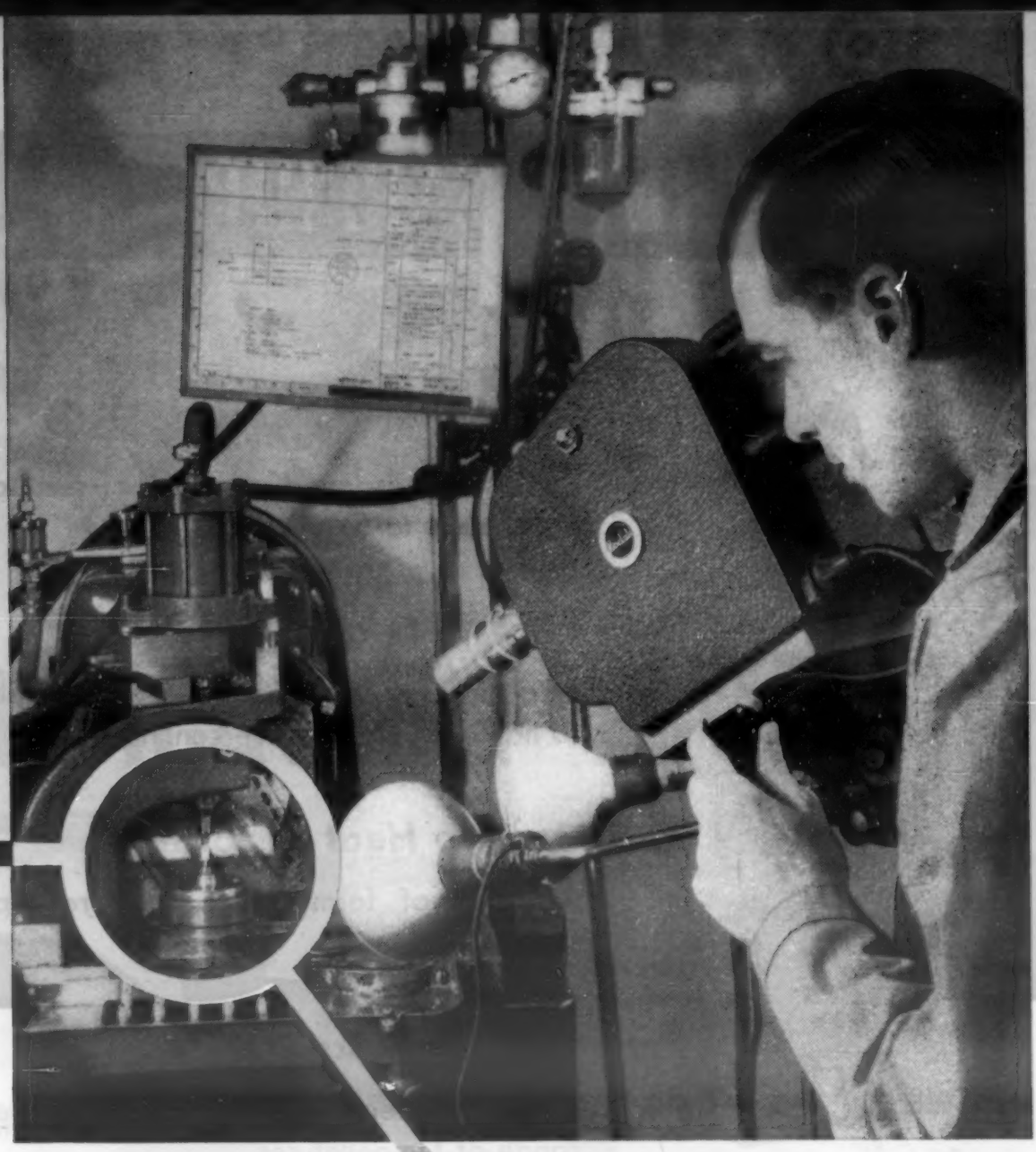
Welding Electrodes

Three additions to its line of low-hydrogen welding electrodes have been made by *Arcos Corp.*, 1500 S. 50 St., Philadelphia 43, Pa. Known as Tensilend electrodes, they eliminate the need for preheat in welding low-alloy high-strength steels in the 70,000, 100,000 and 120,000 psi. tensile strength classes.

Of the three, Tensilend 70 (for the 70,000 psi. class) is believed to have the broadest field of application. Its stainless-type coating and high tensile weld deposit make it suitable for welding low-alloy high-strength steels, mild steels under highly restrained conditions, high carbon steel, and sulfur-bearing free-machining steels. Tensilend 120 (for 120,000 psi. steels) was developed for marine applications, such as welding armor plate, and its further possibilities are still being explored.

These low hydrogen electrodes leave a mild steel deposit which differs from that

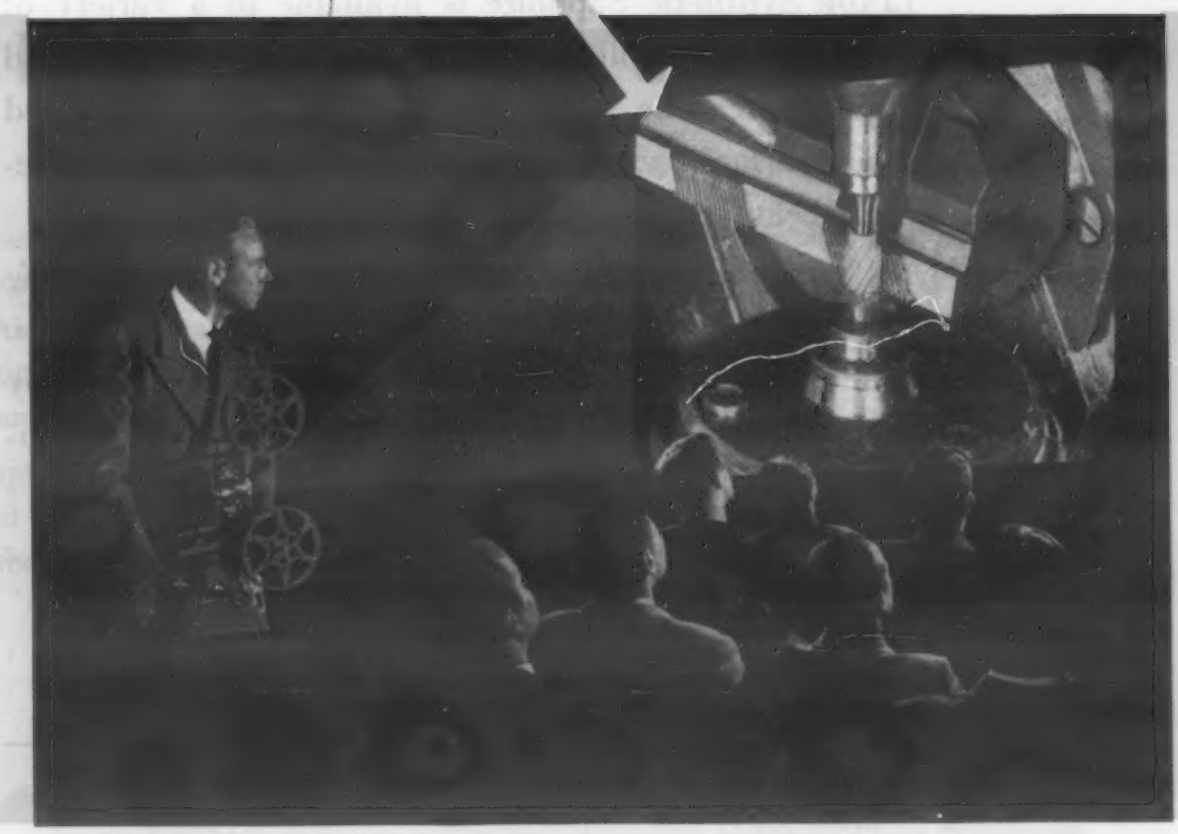
The shortest distance between guessing and knowing



Fast-moving machines are hard to study under actual working conditions. But with high speed movies you can slow down fast action to a pace the eye can follow.

With the Kodak High Speed Camera you can take pictures of your problem (up to 3200 a second on regular 16mm movie film). Then you can see the operation clearly —enlarged on the projection screen—slowed down 200 times! You can *see* the reasons for excessive wear, faulty operation, noise, vibration, or early failure. What you see can point the way to better design, better methods, better performance.

High speed photography is not difficult, and its cost is small compared with the savings it makes possible. For more information, write for the booklet "Magnifying Time" or for loan of the 16mm demonstration film made with the Kodak High Speed Camera.



EASTMAN KODAK COMPANY, Industrial Photographic Division, Rochester 4, N. Y.

High-Speed Movies

...another important function of photography

Kodak
TRADE-MARK

SYNTHETIC SAPPHIRE *for*

Resistance to Wear

Outlasting hardened steel and cemented carbides 2 to 5,000 times.

Resistance to Friction

Affording very low friction surfaces due to hardness and surface continuity.

Resistance to Heat Distortion

Retention of form at temperatures up to 1,000°C.

Retention of Insulating Properties

Excellent dielectric properties over a wide range of temperatures.

LINDE Synthetic Sapphire is available in a variety of forms. It can be polished by flame or ordinary diamond polishing; it can be formed and bent by flame. Polished sapphire surfaces keep free of dirt, and in many anti-friction applications, need not be lubricated.

The experience that LINDE engineers have in applying sapphire to industrial processes may be of help to you. Call or write the LINDE office nearest you. Get your copy of the "Synthetic Sapphire Data Sheet", and the "Synthetic Crystal Stock List" of forms available.

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Unit of Union Carbide and Carbon Corporation
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The term "Linde" is a trade-mark of The Linde Air Products Company.

New Materials and Equipment

of most mild steel electrodes in possessing higher tensile strength, better elongation and better impact strength at both room and freezing temperatures.

Arc Welder

An a.c. arc welder, designed for inert gas-shielded arc welding and possessing fast hydraulic amperage control, has been announced by *Miller Electric Manufacturing Co.*, Appleton, Wis.

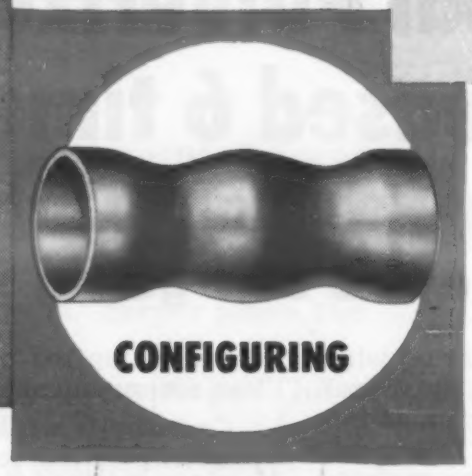
The hydraulic amperage control enables the operator to make instant amperage changes without leaving the work and with-

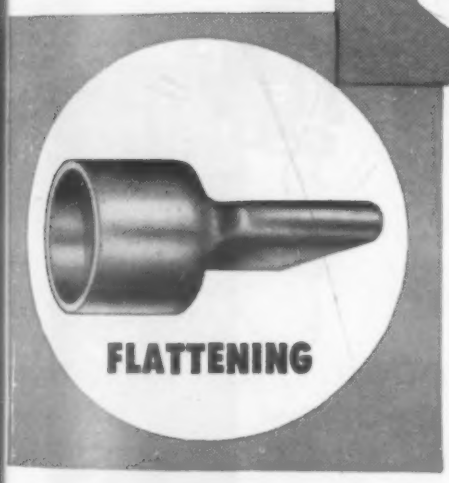
The new Miller arc welder has fast, hydraulic amperage control.

out breaking the arc. Gradual changes are also possible. Since heat can be reduced quickly or slowly at the option of the operator, craters at the end of the weld can be eliminated. Also, the operator can start with a lower heat on thin-gage material and then increase heat as desired—or the reverse procedure for heavier materials.

The welders are supplied in three amperage ranges—10 to 200, 10 to 400 and 10 to 700 amp., in either "A" or "B" models. The "A" models have two foot control switches: one for power and high frequency, the other for amperage. Gas and water are automatically controlled. The "B" models have only one foot switch for controlling amperage. Power, high frequency, gas and water are automatically controlled.

Severe Fabrication?





ELECTRUNITE TUBING
...Takes it with ease

There's a mighty good reason why ELECTRUNITE Tubing stands out for forming operations like these. It's Republic's ELECTRUNITE Process in which highest quality flat rolled steel is cold formed and welded into strong, sound tubing. As a result every length is uniform throughout—in roundness, diameter, wall thickness and ductility . . . free from defect, inside and out.

Republic ELECTRUNITE Tubing is available in a full range of sizes, gages and analyses – both carbon and stainless steels. See your nearest Steel and Tubes Representative or write today for a free copy of booklet No. 22.

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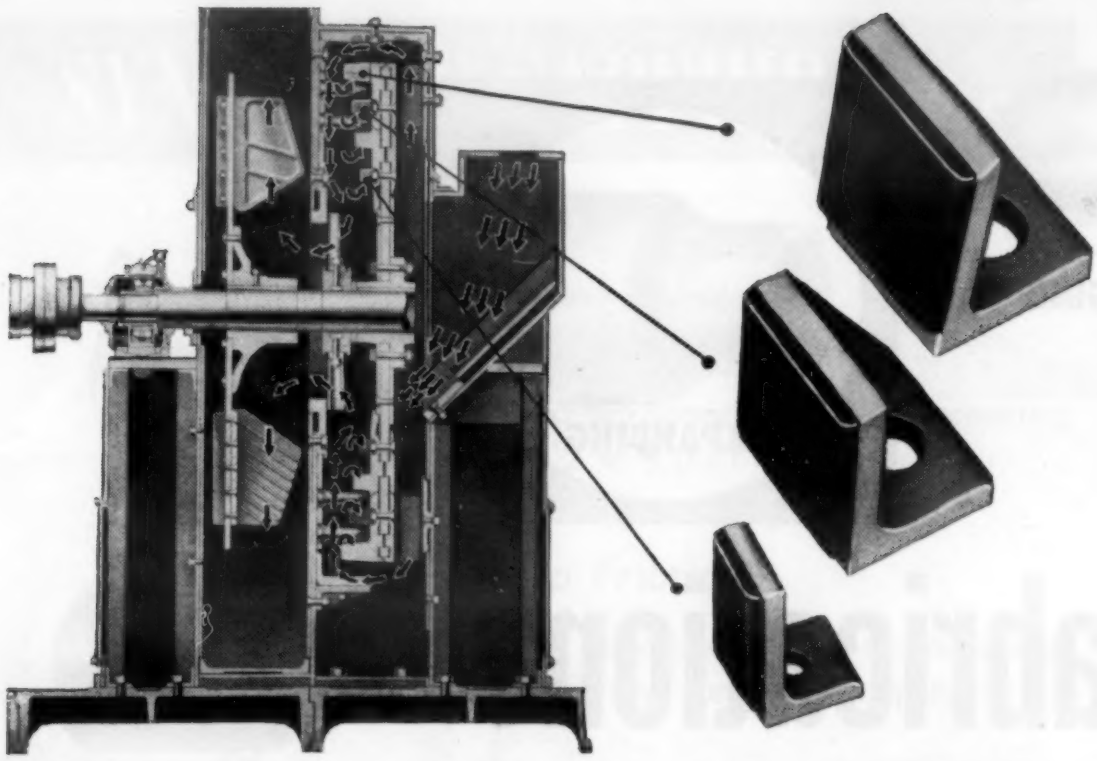


Life of Coal Pulverizer Pegs increased 6 times

by Wear-Resistant Carboloy

. . . and they're still going strong!

STEEL couldn't stand the grind when it came to pulverizing "soft" coal. When an industrial stoker manufacturer used steel "pegs" on rotary coal pulverizers, they had to be replaced after handling only 3,500 tons.

Then he switched to "pegs" faced with Carboloy Cemented Carbide. After pulverizing 22,000 tons—more than 6 times as much as steel—they were still going strong and showed no appreciable wear.

Everyone gained through this change to Carboloy. The stoker manufacturer came up with a powerful, new selling point. Users saved time and money through continuous operation of boilers. There were no shutdowns to replace "pegs", no time was lost for maintenance.

Carboloy is working similar wear-proofing miracles in dozens of industries. This *hardest metal made by man* was developed specially to combat wear. In some cases it has increased the life of machine parts or products by *as much as 100 times.*

There's a good chance that Carboloy can eliminate costly downtime and parts replacement in your machines, or add extra life and efficiency to your products. Write today and arrange for a Carboloy engineer to call and talk things over. Carboloy Company, Inc., 11161 E. 8 Mile Ave., Detroit 32, Michigan.

Where Can You Use These Outstanding Characteristics of Carboloy?

1. Hardness
2. Compressive strength
3. Abrasion resistance
4. Corrosion resistance
5. High red hardness
6. Low coefficient of thermal expansion
7. High modulus of elasticity
8. Impact strength
9. High density
10. High polish retention
11. Low electrical conductivity
12. Non-magnetic (if desired)

WHEREVER THERE'S MOTION THERE need not be ~~IS~~ WEAR

CARBOLOY® CEMENTED CARBIDE HARD METAL

The Versatile Metal of Industry

New Materials and Equipment

Small-Size Electrode

The recently announced Steel-Tetic el trode for mild steel is now available in smaller diameter, 3/32 in., according to announcement by *Eutectic Welding Alloys Corp.*, 40 Worth St., New York 13. T smaller electrode is intended to extend t use of low amperage metallic arc weldi to extremely thin gage steel.

Spot Welding Accessory

A self-contained unit designed to add t advantages of air-pressure operation to re lar foot-controlled rocker arm type sp welders is being manufactured by *Robt. Hoffman Co., Inc.*, 32 St. Clinton St., C cago 6, Ill.

The device, called Weld-Air-Matic, clam

The Weld-Air-Matic spot welding devic available in three standard sizes.

to the upper horn of conventional rock arm spot welders and works on a reduc air pressure of 15 to 50 psi., dependi upon requirements.

An electric foot switch controls the a pressure; a minimum line pressure of 8 psi. and air supply of 4 cu. ft. per min. a required. Eliminating the necessity for a rocker arm movement, the device operat through a maximum stroke of 1½ in. o size 1 welder, 2 in. on size 2, and 2½ i on size 3. The unit is designed to work conjunction with any standard weld tim control.

unusual flexibility.....

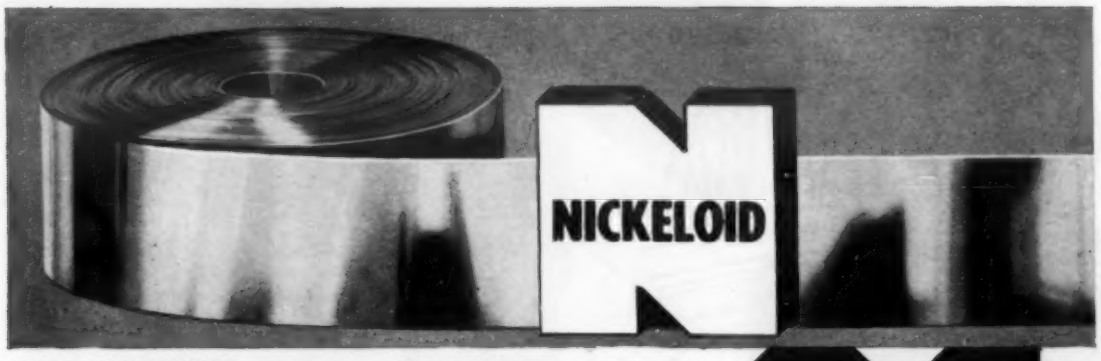
Although it is but one instrument, the organ can reproduce a single musical pattern in a multitude of tones and varied effects. Sivyer offers the same unusual flexibility in castings. The composition, the characteristics of a casting... even though the pattern is the same... can be varied to suit a wide range of needs or conditions. This flexibility can mean extra economy, increased efficiency in many ways for the shrewd buyer of steel castings.

one casting... IN A VARIETY OF ALLOYS

SIVYER

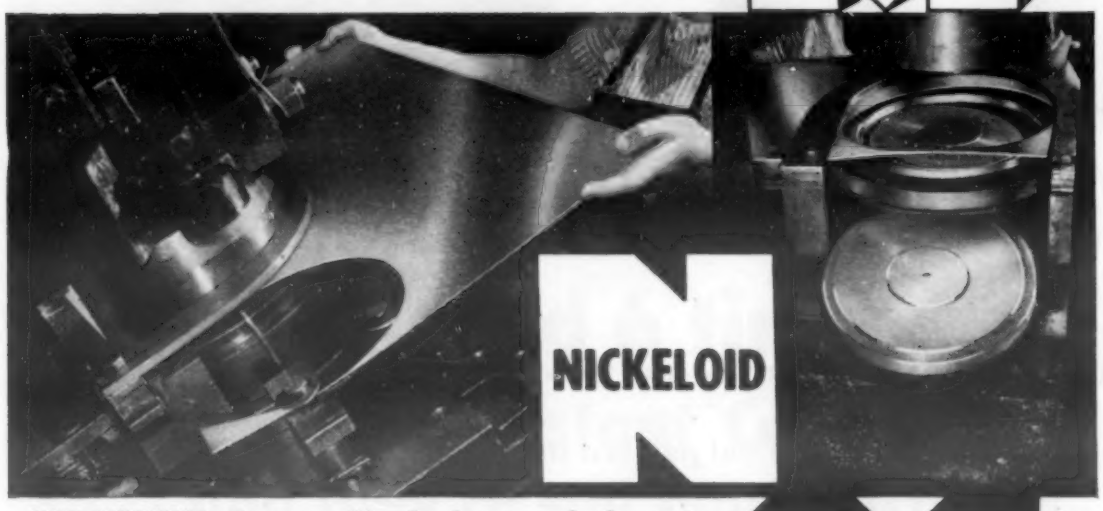
SPECIALISTS IN HIGH ALLOY AND SPECIFICATION STEEL CASTINGS

SIVYER STEEL CASTING COMPANY • MILWAUKEE CHICAGO



LUSTROUS FINISHES, patterns, add beauty to any product.

It's More Than a **METAL**



JUST FABRICATE, then assemble, for lower production costs.

. . . It's Also a **METHOD**

In any re-design program, Nickeloid Pre-Finished Metals are something the Product Designer and Production Head can shake hands on. For Nickeloid Pre-Finished Metals not only offer the designer an inspiring, lustrous material — they also offer the production man a faster, lower-cost method — just *fabricate*, then *assemble!* What material could offer more?

Nickeloid Metals are available in sheets or coils, in a wide range of gauges and tempers, plated one or two sides, bright or satin finishes of Chromium, Nickel, Brass, or Copper, plated to base metals such as Steel, Zinc, Brass, Copper or Aluminum.

Write for new "Sampler" containing representative samples of Nickeloid *pre-plated* Metals.

NICKELOID METALS (Pre-Plated)

NICKEL · CHROMIUM · BRASS · COPPER
Electro-plated TO ALL COMMON *Base* METALS
ALSO LACQUERED COLORS
SHEETS AND COLOS

OLDEST AND LARGEST PRODUCERS OF PRE-PLATED METALS

Established 1898

AMERICAN NICKELOID COMPANY

PERU 6, ILLINOIS

New Materials and Equipment

Electrode Holder

A 500-amp. electrode holder of the bla type, taking 3/8-in. electrodes, is being ma by *Jackson Products*, Warren, Mich. Know as the BT-5 holder, it has 7/8-in. wi spring steel jaws, grooved to hold rods four different angles in either right or l hand.

Cables can be brazed, soldered clamped to the copper alloy cable connec The holder is well-insulated.

Forming

Bench Punch

A bench punch having a particular high and deep throat is being manufa tured by *Whitney Metal Tool Co.*, 19 Forbes St., Rockford, Ill. The 7-in. dep and 5-in. height of the throat enables t Whitney-Jensen No. 18 Bench Punch

Whitney-Jensen No. 18 Bench Punch fe tures high, deep throat.

punch holes close to the web of an angl In addition, a removable and adjustable d shoe permits use of close fitting punch and dies.

The machine is a roller bearing, leve type punch. Maximum capacity of the to is a 13/15-in. round hole through 12-ga mild steel. A convenient work table, 10

This REFERENCE BOOK on *Forgings...*

...It can help you reduce cost at the point of assembly!

There are thousands of instances where forgings have reduced the cost of parts at the point of assembly. This booklet containing 60 pages of authoritative information on forgings formed to close tolerances by the use of closed impression dies tells how cost of reductions may be obtained. Forging production techniques are described and illustrated.

Forgings provide rapid assembly of complex parts by welding adaptability of widest range; forgings permit reduction of dead weight because maximum strength and toughness are obtainable in lighter sectional thicknesses; forging to shape avoids waste of metal and reduces machining and finishing time-cost. The metal quality and cost-reducing possibilities obtainable in forgings cannot be equalled or duplicated.

Recheck every stressed part in your equipment, as well as simple handles and levers, and consult a forging engineer about possibilities for reducing costs at the point of assembly. Only a forging engineer can inform you fully regarding the numerous advantages obtainable with forgings. Your copy of this reference booklet on forgings is available now. Attach coupon to your business letterhead.

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Please send 60-page booklet entitled "Metal Quality—How Hot Working Improves Properties of Metals" 1949 Edition.

Name..... Position.....

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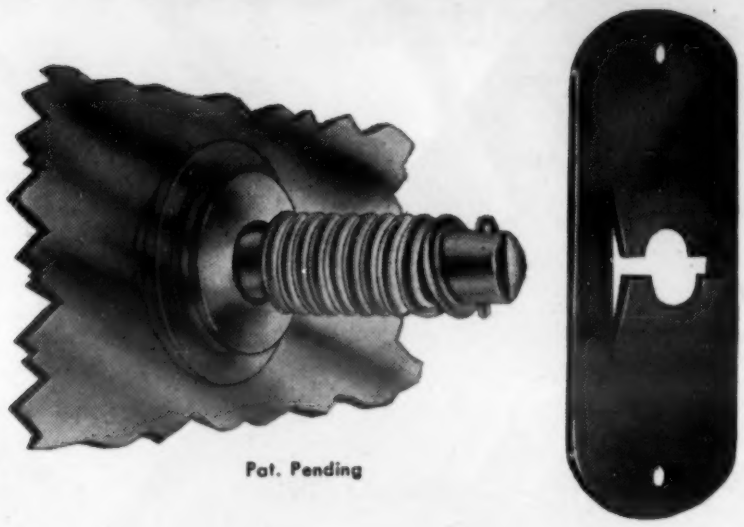
For your toughest Fastening Job—

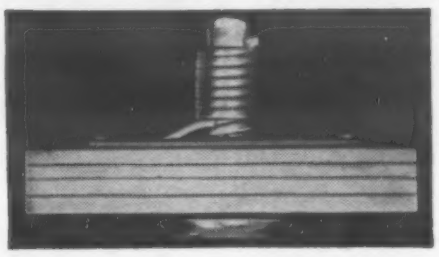


Pat. Pending

The removable-panel fastener with coil-spring thread that DEFIES VIBRATION

HERE'S HOW THE SPRING THREAD WORKS:

- It actually **grips** the Tinnerman speed nut, resisting vibration and panel movement. The spring's unique design creates both tension and compression in holding panels.
- It absorbs shock—allows motion that exists in most mechanical assemblies to take place without disturbing engagement of the fastener.



One screw length will accomodate panels ranging in total thickness from .075" to .500". Only one size need be stocked. Easy to install, the SOUTHCO Spring-Grip Fastener holds panels under maximum compression.

Doors, access panels, inspection plates, etc. positively will not work loose in the presence of vibration or panel movement when secured by the Spring-Grip Fastener's positive gripping action. Even when panels are partially disengaged, the spring-thread holds them firmly in their relative positions.

the new SOUTHCO

SPRING-GRIP FASTENER

WRITE TODAY FOR COMPLETE INFORMATION

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1418 South Penn Square
Philadelphia 2, Pa.

SOUTHCO ®

New Materials and Equipment

10 in. with tapped holes for locating si and back gage bars is available. Standa Whitney-Jensen punches and dies, in wide range of sizes, can be used on th punch, but irregular shaped punches an dies are also available from the manufa turer.

Drawing Compound

A new drawing compound, Hough Draw 357, has been developed for co drawing of hot or cold rolled bars or ro by *E. F. Houghton & Co.*, 303 W. Lehi Ave., Philadelphia 33, Pa.

The compound is a heavy paste co taining high-melting waxes and fats com bined with a colloidal pigment. It has hig adhesive properties and is applied by im mersion of the work in a tank containi a solution of the compound, 5 oz. to gallon of water, maintained at 170 F.

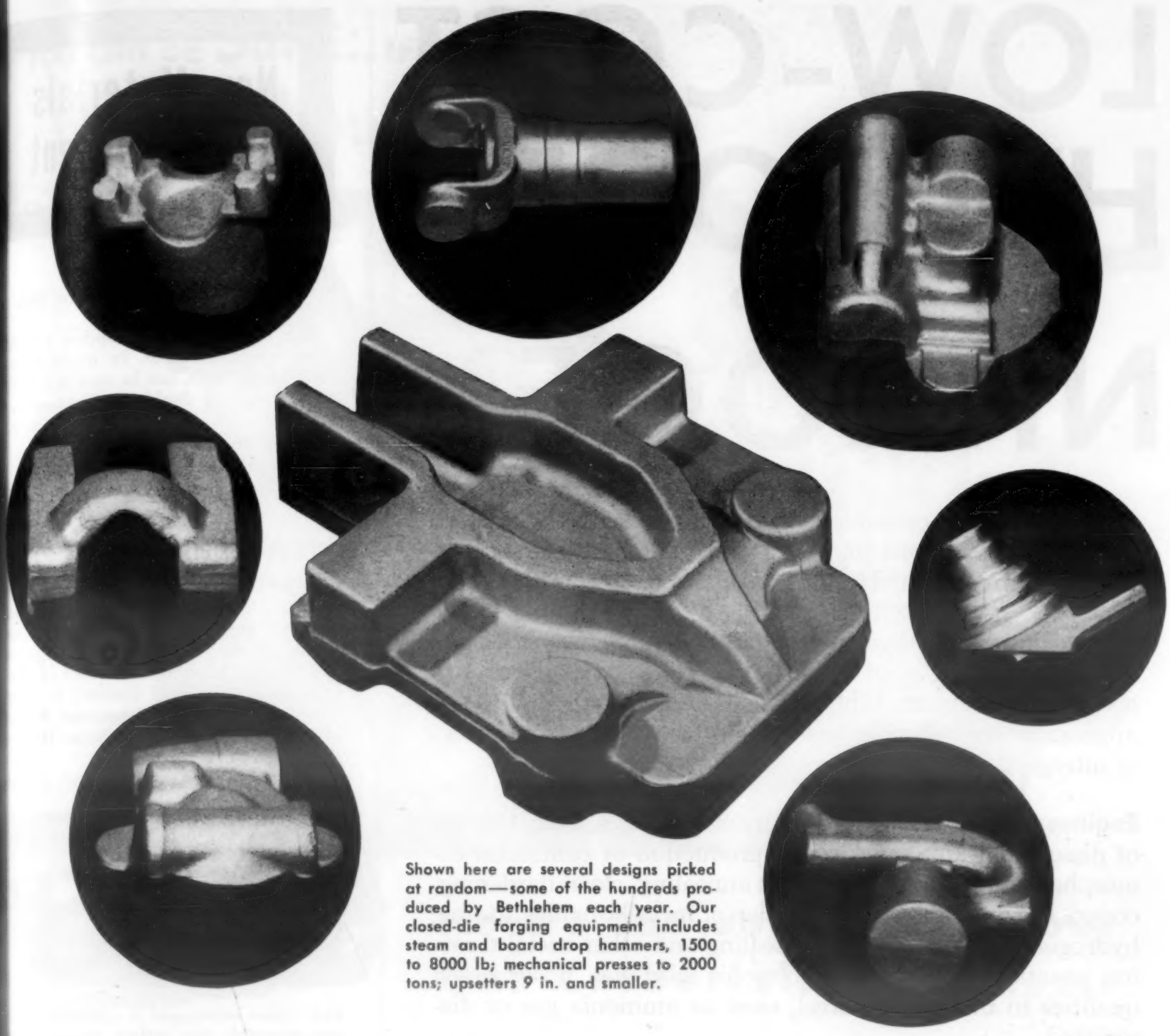
Bars are ready for drawing after drainin and air drying. Bars drawn with this ne compound are claimed to have bright and smoother finish than those lubricate by slower and dirtier liming practice.

Testing & Inspection

Double Monochromator

An instrument for spectroscopic analys in any region of the ultraviolet, visible an infrared ranges of the spectrum betwee 0.2 and 35.0 microns is available fro

The Farrand Double Monochromator is flexible instrument for spectroscopic ana yses.



Shown here are several designs picked at random—some of the hundreds produced by Bethlehem each year. Our closed-die forging equipment includes steam and board drop hammers, 1500 to 8000 lb; mechanical presses to 2000 tons; upsetters 9 in. and smaller.

At Bethlehem . . . an almost endless variety of DROP FORGINGS

Bethlehem is so well equipped for drop-forging work that innumerable designs can be handled in weights ranging from 1½ to 200 lb.

This means, of course, that we are able to serve the needs of many different industries—automotive, petroleum, aviation, electrical, and numerous others.

At Bethlehem the drop-forging service begins with the making of the steel, carbon or alloy, and carries through all the operations of die-sinking, forging, treating, cleaning, etc. Every phase is under our direct control, enabling us to check and double-check on quality all the way through.

Let us bid on your future business. We have much to offer that every user of drop forgings should know about.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

LOW-COST HYDROGEN AND NITROGEN

YOU effect real economies when you use Barrett Standard Anhydrous Ammonia as a replacement for other more expensive sources of hydrogen and nitrogen.

Barrett Standard Anhydrous Ammonia (Refrigeration Grade) contains a minimum of 99.95% NH_3 and is oxygen free with a very low dew point. When dissociated, each pound produces approximately 34 cubic feet of hydrogen and 11 cubic feet of nitrogen.

Engineers have discovered many advantages from the use of dissociated ammonia in the production of controlled atmospheres in furnaces for bright annealing, clean hardening, copper brazing, sintering, reduction of metallic oxides, atomic hydrogen welding, radio tube sealing and other metal-treating practices. Anhydrous ammonia also has unsurpassed qualities in nitriding of steel, used as ammonia gas or dissociated.

Barrett Standard Anhydrous Ammonia is available in 150, 100 and 50-pound cylinders from stock points conveniently located from coast to coast; or, for larger users, in tank car shipments from Hopewell, Virginia, and South Point, Ohio.

The advice and help of Barrett technical men are available to Barrett customers without charge. For information, contact Barrett, *America's leading distributor of ammonia.*

Barrett*

STANDARD ANHYDROUS AMMONIA

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N.Y.

*Reg. U. S. Pat. Off.

New Materials and Equipment

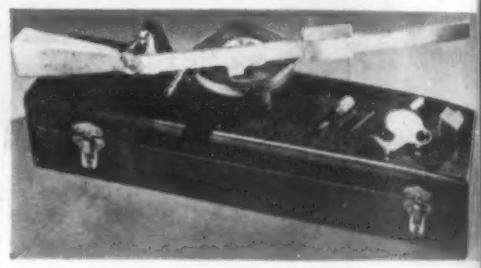
Farrand Optical Co., Inc., Bronx Blvd. & E. 238 St., New York 66.

The optical system comprises a double monochromator which, by means of auxiliary components, can be used as a double spectrometer or double spectrophotometer. The compact unit is claimed to be flexible and easy to use.

Scratch Tester for Plastics

A precision tool for testing the ability of plastic materials and plastic-coated surfaces to resist scratches, digs, scrapes and similar physical damage not classed as normal wear is being manufactured by *Taber Instrument Corp.,* 109 Goundry St., North Tonawanda, N. Y. The instrument is known as the Model 139 Taber Shear Hardness and Diamond Scratch Tester.

Both tests are performed with a finely



This Taber instrument is claimed to measure accurately the surface toughness and scratch resistance of a plastic or coated surface.

balanced scale beam, calibrated in grams, to which is attached the Taber S-20 or S-30 Precision Ground Contour Shear Tool or the 139-55 Diamond Point Scratch Tool. The tool is adjusted so that it rests against a clear area of the specimen to be tested. The sliding weight is moved part way along the scale beam and a cut or scratch is made by turning the specimen by hand slowly and steadily in a counterclockwise direction. The results are then calculated in accordance with instructions furnished with the instrument.

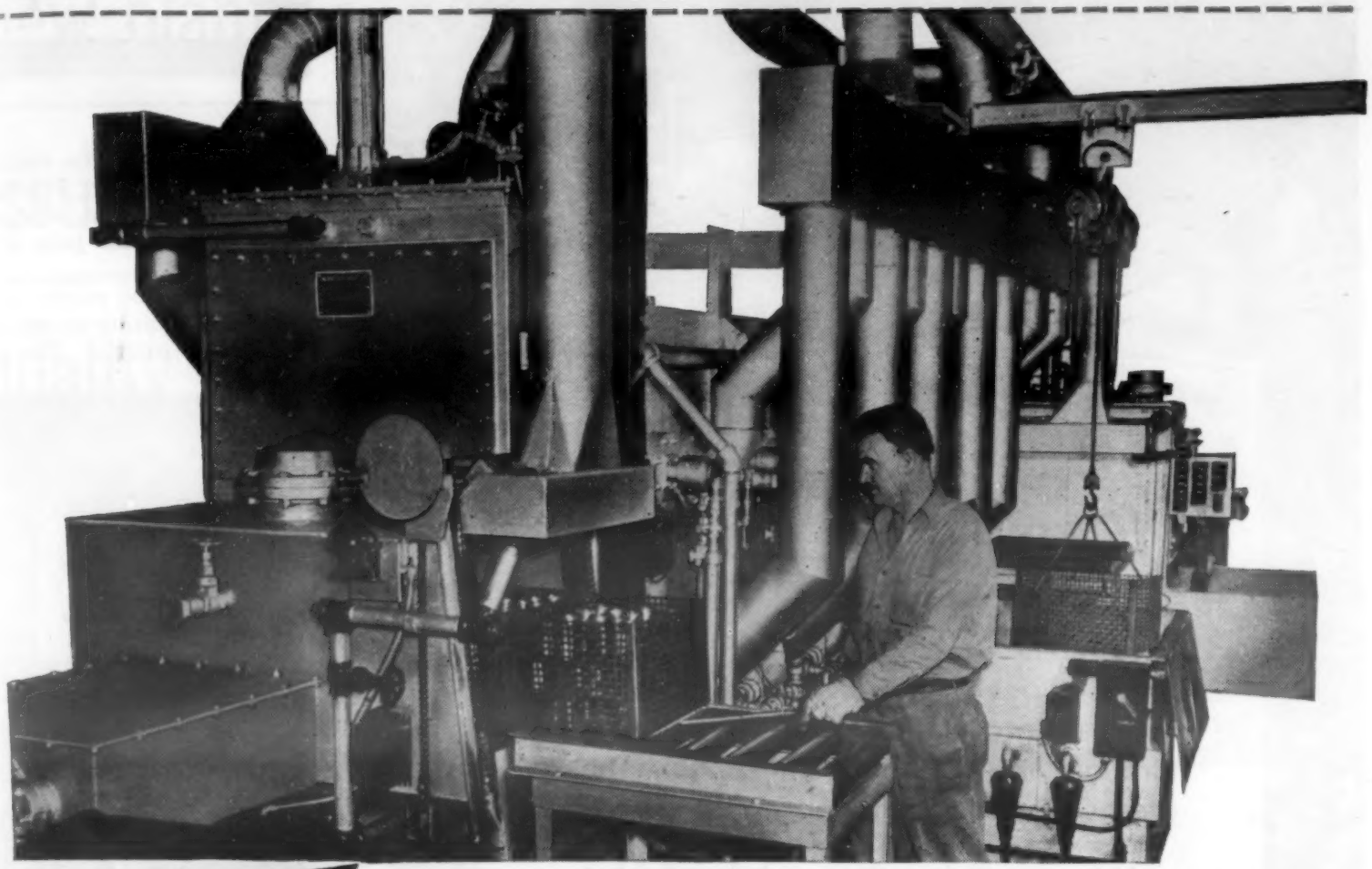
Electron Microscope

A greatly simplified, table-model electron microscope offering direct magnifications up to 6000 diameters for metallurgical investigations has been introduced by *RCA Victor Div.* of *Radio Corp. of America,* Camden, N. J.

Called the RCA Permanent Magnet Electron Microscope, it has the same 50,000-volt accelerating potential as this company's Universal model. Magnifications up to 50,

YOU CAN BE SURE.. IF IT'S

Westinghouse



FOR THE MAN WHO CAN'T BE SOLD

Here's the solution to your Gas Carburizing Problems

Westinghouse Therm-a-neering has the answers. This engineering and metallurgical service is offered with no obligation to the man who "can't be sold", but, who is willing to accept *proof* of efficiency and dependability. Therm-a-neering custom-builds equipment to fit your individual requirements, assuring smooth and economical operation of your heat-treating line.

Take the carburizing furnace shown above, for example: one continuous and complete operation puts all parts through the same cycle, same atmosphere, same temperature. Uniformity of parts is assured. Rejects are eliminated.

And the work is done fast. No handling of parts is required between charging and discharging. Doors open automatically. One operator handles all work easily. Production is maintained at 800 net pounds per hour.

This installation is typical of the way Westinghouse furnaces—both gas-fired and electric—are answering today's production problems. And because Westinghouse engineers have no favorite to play, they can study your problems from an unbiased point of view in helping you select the equipment to do your job most efficiently and economically.

Let Therm-a-neering help you. Call your nearby Westinghouse representative for details, or write Westinghouse Electric Corporation, 180 Mercer St., Meadville, Pa. J-10350

Therm-a-neering. A HEAT AND METALLURGICAL SERVICE THAT OFFERS WITHOUT OBLIGATION:

ENGINEERS—Thermal, design and metallurgical engineers to help you study your heat-treating problems with a view toward recommending specific heat-treating furnaces and atmospheres.

RESEARCH—A well-equipped metallurgical laboratory in which to run test samples to demonstrate the finish, hardness and metallurgical results that can be expected on a production basis.

PRODUCTION—A modern plant devoted entirely to industrial heating.

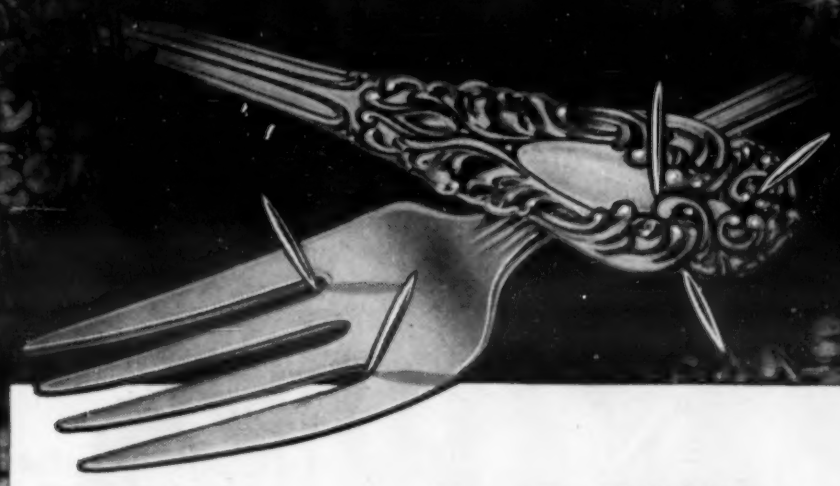
EXPERIENCE—Manufacturers of a wide variety of furnaces—both gas and electric—and protective atmosphere generators.

Westinghouse

GAS AND ELECTRIC

Furnaces

in BURNISHING MATERIALS



THE "PIN" HAS ITS POINTS

Pin-point probing into sharp crevices, filigree, small recesses and other hard-to-reach spots is the special burnishing function of Abbott Burnishing Pins. They are pointed to do the job right!

Abbott Burnishing Materials, available in five shapes . . . Ball, Ovalball, Cone, Pin, Diagonal . . . are scientifically designed to make effective contact on metal stampings or castings of any size and shape. Each piece is a burnishing tool made from Abbott's high quality bearing ball steel. Each is deep hardened and polished to a mirrorlike glass-hard finish. Make it a ***point*** to get better burnishing results in those tight corners . . . use Abbott!

Abbott Burnishing Materials are available in a variety of sizes and mixtures. Send for catalog giving complete information. No obligation.

THE ABBOTT BALL COMPANY

1074 New Britain Ave., Hartford 10, Conn.

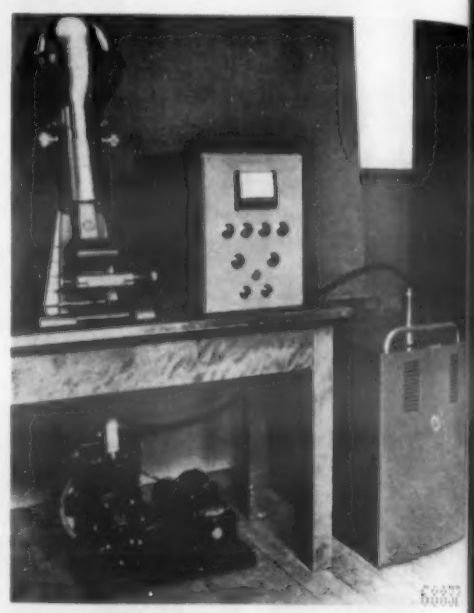
ABBOTT

the all round ball

New Materials and Equipment

000 diameters can be obtained by photographic enlargement. The new instrument, only 30 in. in height, is expected to sell for about one-third the price of the Universal model.

The new model employs permanent magnet lenses requiring no stabilization circuits or auxiliary controls. The instrument also

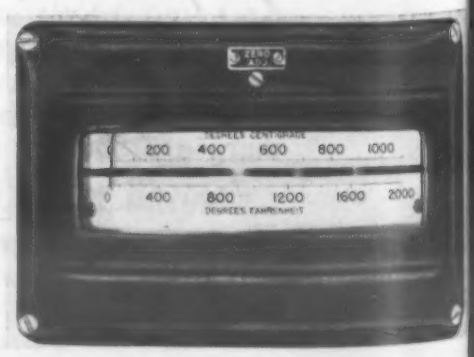


Shown here are the microscope proper (left) and control unit. Beneath the table is the vacuum pump and, on floor at right, the high-voltage power supply.

permits insertion of specimens into the evacuated column and their removal without breaking the vacuum. In addition, photographic plates can be changed without admitting more than a small amount of air to the column. As a result, pumping time between plates is reduced to only 90 sec.

Pyrometer

A compact indicating pyrometer, Model 192, for flush and surface mounting has been announced recently by *Wheelco Instruments Co.*, 847 W. Harrison St., Chicago 7, Ill. It is designed for those applications where size of the heating equipment

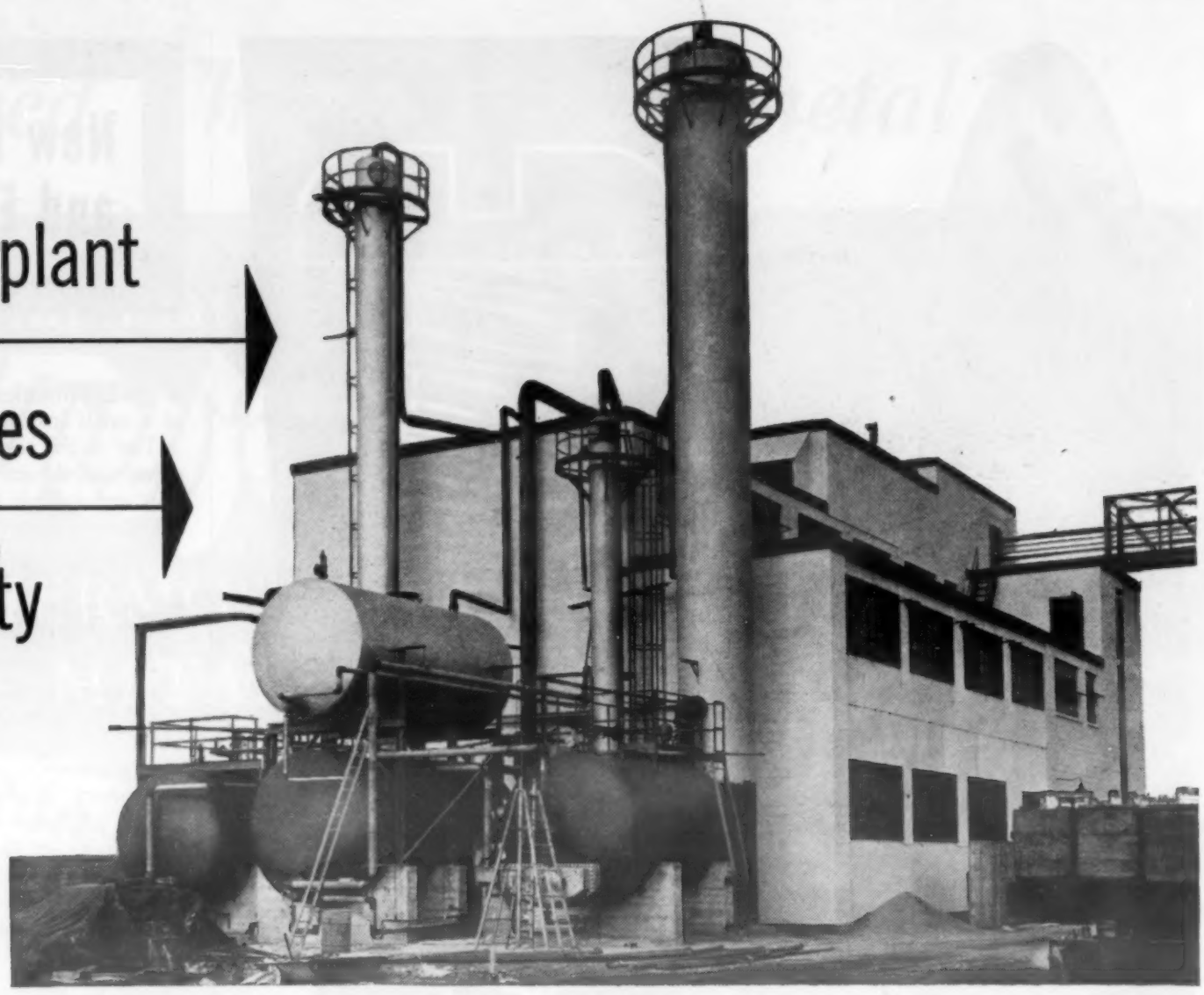


The new Wheelco pyrometer, Model 192, is 7½ in. wide and 5 in. high.

this new plant

assures

quality



NIALK TRICHLORethylene

Are you looking for a thoroughly dependable source of supply for trichlorethylene?

Niagara's new plant for the production of NIALK TRICHLORethylene is completely modern and makes use of special control equipment to satisfy the most exacting requirements for quality and stability.

It is designed to permit increased production facilities—to meet expanding demands.

This coupon brings you a pamphlet which answers all your questions about NIALK TRICHLORethylene. Fill in and mail today.

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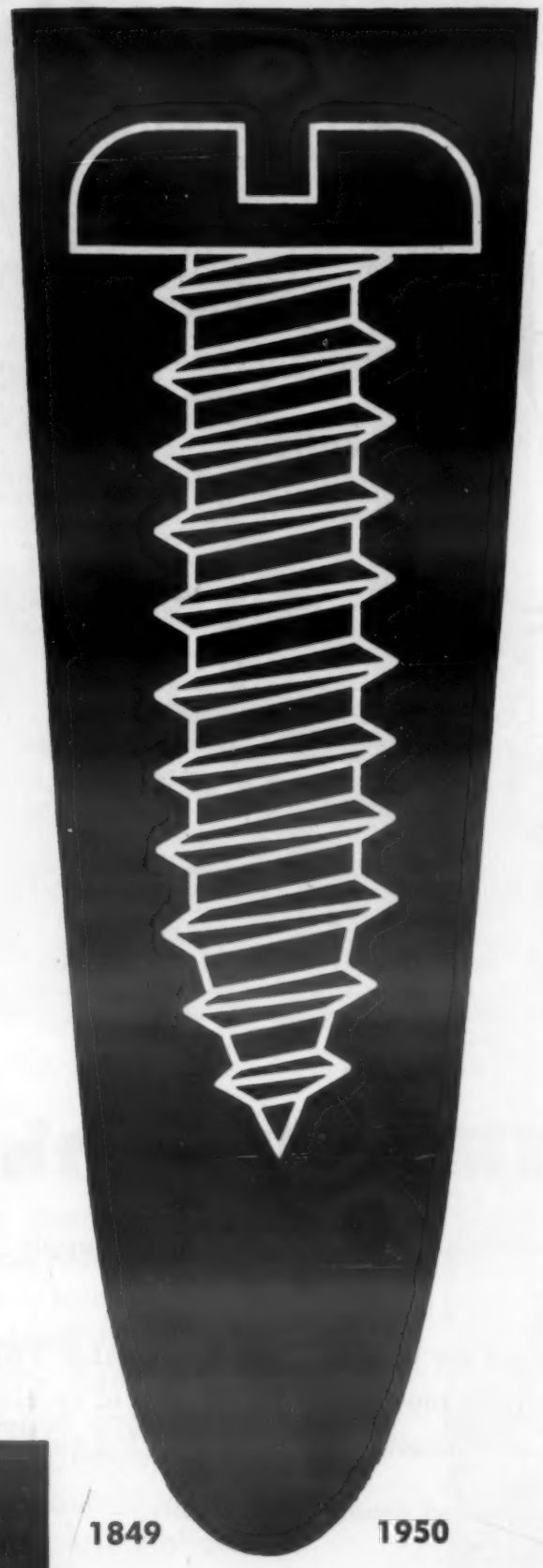

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Fastenings

Slotted or Phillips head machine screws, wood screws, stove bolts, tapping screws, special headed products; nuts, rivets, chaplets, wire forms, screw machine products . . . in steel, stainless steel, copper, brass, bronze, everdur, nickel, nickel silver, monel, aluminum . . .

THE BLAKE & JOHNSON COMPANY, WATERVILLE 48, CONN.

Please send me your new catalog containing full data on the complete line of Blake & Johnson fastenings.

Name.....

Title.....

Company.....

Address.....MM-6

New Materials and Equipment

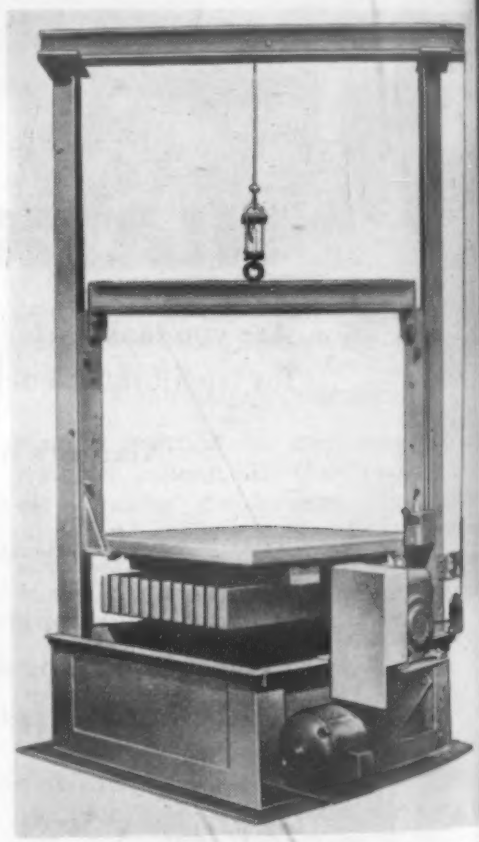
or space limitations make necessary the use of a small instrument.

The high resistance "edgewise" movement with Alnico V magnet and wide open mirrored scale is fully compensated and enclosed in a dustproof housing.

Shock Testing

A shock testing machine for testing in accordance with government specification AN-E-19, is being marketed by *The Barry Corp.*, 179-S Sidney St., Cambridge, Mass. The machine is called Type 150 VD Impact Shock Machine.

The platform will handle equipment as large as 36 by 36 by 30 in. high, weighing up to 150 lb. Steel-sheathed blocks, attached



This shock testing machine is available from The Barry Corp.

to the under-side of the platform, penetrate the sand in the box at the end of the drop to give a single deceleration pulse without rebound. The number and arrangement of blocks governs the decelerating force and the duration of the pulse. Calibration curves show the relation between height of fall, maximum deceleration and duration of deceleration pulses for various arrangements of control blocks. Decelerations up to 100 times gravity can be obtained, and duration of deceleration can be adjusted between 6 and 32 milliseconds.

The machine is 10 ft. 6 in. high, requires 4-ft. 2-in. by 5-ft. 1-in. floor space, and weighs 3000 lb.

Need Thin Gage Bimetal?

Have you a thermostat metal problem requiring exceptional thin gage metal? General Plate can provide the solution with *Truflex* bimetal in thicknesses down to .0005" or ¼ the thickness of a human hair. And even in this unusual thinness, every succeeding order comes to you an exact duplicate of the original . . . uniform in tolerances, temperature reaction and performance.

General Plate thin gage Truflex Thermostat metal applications include instruments, thermometers and electronic equipment . . . as quick-acting thermostats where space and mass is at a premium . . . as thermal compensating coils or springs in thinner than "hairspring" dimensions.

General Plate manufactures Truflex Thermostat metal in a complete line of combinations to meet practically all requirements. It is available in strip, coils, sheets, ranging in widths from .020" to 8" . . . or in fabricated parts ready for installation into your products. Write for information and engineering assistance.

OTHER GENERAL PLATE PRODUCTS INCLUDE

- Precious to base metal laminations
- Base metal laminations
- Alcuplate (copper or aluminum)
- Silver solders
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- Platinum-fabrication-refinery
- Age-hardening Manganese Alloy 720

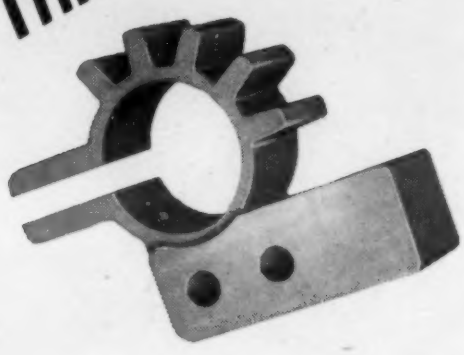
GENERAL PLATE

Division of Metals and Controls Corporation

606 FOREST ST., ATTLEBORO, MASS.

50 Church St., New York, N. Y. • 4326 N. Elston Ave., Chicago, Ill. • 757 W. Third St., Mansfield, Ohio • Detroit, Mich. • Los Angeles, Calif.

You can "Duck" This Problem



It is simple when you make this part as a Precision Investment Casting.

Why go through all the expensive tooling and high cost procedure of trying to machine a difficult part like this by conventional methods?

Designers sometimes bring out queer looking gadgets but they have a purpose or function and you may be surprised how cheaply many of these can be produced by Precision Investment Casting.

Please use the coupon.

GRAY-SYRACUSE Inc. . . . . .

107 N. Franklin St., Syracuse 4, N. Y.

Small precision castings of ferrous and non-ferrous alloys.

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Please send me literature on Precision Investment Castings.

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New Materials and Equipment

General

Induction Heating

A combination work table and quench tank that can easily be attached to its vacuum tube or spark gap converters has been introduced by *Lepel High Frequency Laboratories, Inc.*, 39 West 60 St., New York City.

With sink cover on, this combination unit forms a 29- by 56-in. work table for mounting work coils and fixtures. The

Inset view of new Lepel equipment shows sink with Lepel Roto Heating and Quenching Unit.

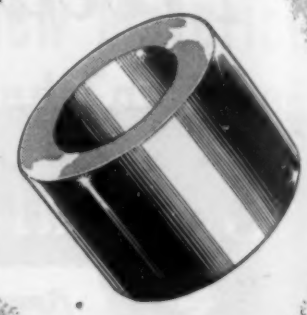
center part of the table-top can be removed, uncovering a brass (or stainless steel) quench tank 24 by 24 by 18 in. deep, fed by a 1-in. water line, solenoid controlled. This sink can be used for water, oil or brine quenching. It will also accommodate the Lepel Roto Heating and Quenching Unit, designed for hardening gears, blanks, etc.

Die Casting Machine

A self-contained, all-hydraulic machine for producing die castings of magnesium, aluminum or copper-base alloys has been developed by the *Hydraulic Press Manufacturing Co.*, Mount Gilead, Ohio. Model 400-M has a die clamping pressure of 400 tons and a maximum production of 125 shots per hr.

High sustained injection pressure through the cold chamber injection system makes possible castings relatively free of porosity. Both die opening and closing are easy and free of shock, thus adding materially to die life and reducing casting scrap loss to a minimum. Die openings are controlled through electric timers, and automatic control of die movement, clamping and injection plunger movement is included. A hydraulic actuating cylinder provides for automatic ejection of the casting.

WORKS WHERE OTHERS WON'T



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GRAPHALLOY OILLESS BEARINGS

SPECIFY GRAPHALLOY TRADE MARK REG. U. S. PAT. OFF. WITH CONFIDENCE

SELF-LUBRICATING ● EXTREMELY DURABLE ● CONSTANT CO-EFFICIENT OF FRICTION ● OPERATES DRY — OR *SUBMERGED IN WATER, GASOLINE OR CORROSIVE LIQUIDS* ● APPLICABLE OVER A WIDE TEMPERATURE RANGE — *even where oil solidifies or carbonizes* ● EXCELLENT AS A CURRENT-CARRYING BEARING.

GRAPHITE METALLIZING CORPORATION

1010 NEPPERHAN AVENUE, YONKERS 3, NEW YORK

One of a Series of
Messages to the Buyer
of Custom Molded Plastics

All Ways Alike!

"Statistical Quality Control" goes *Mrs. Pod* more-than-one better!

The original *Mrs. Pod,* unconcerned about specifications, delivers nature-molded pieces which, to the eye, need only *look alike* in appearance and size!

"Statistical Quality Control" goes much further. As a special production-improvement factor . . . and with the custom molder's press as its *pod,* each delivered part must fully comply with each and every required specification! Not only must parts look alike—they must be alike! . . . Size—shape—molding uniformity — precision placement of inserts — together with a multiplicity of inside and outside measurements . . . all, in *all* ways, must pass rigid tests before passing to the customer.

With "Statistical Quality Control" in force, few parts ever get the chance to develop an inferiority complex. The method raises the standard of an entire output and saves the customer the need and the cost of double inspections.

Whenever you are projecting a part — to be molded of plastic—and one that must toe the specifications line—call in a Consolidated sales engineer. Any one of our quickly reached offices is ready to apply experience, know-how and savings to your custom plastics problem.

Please address Dept. E-6

"STATISTICAL QUALITY CONTROL" *at Work!*

The system, one of scientific sampling, is documented by regular timings, gauge readings, jig constructions, graph plottings. In the hands of Consolidated's skilled plastics technicians, "S. Q. C." can't help but insure you the kind of plastics production that makes for a strong custom-molding relationship.

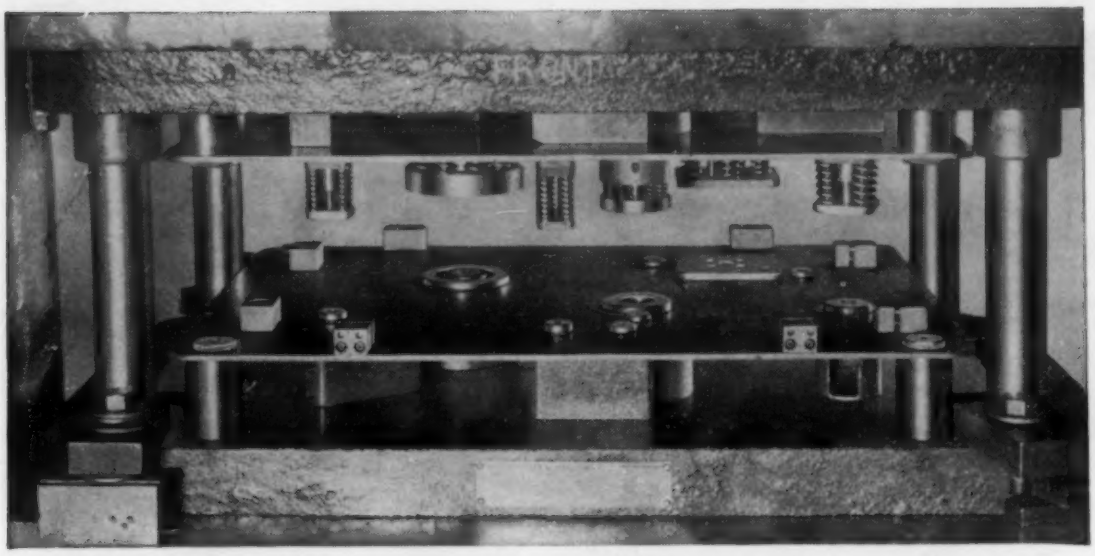
Consolidated *Molded Products Corporation*

Plant & Executive Offices: **309 CHERRY ST., SCRANTON 2, PA.**

Branch Offices and Representatives in New York, Chicago, Detroit, Cleveland, Bridgeport, Philadelphia—*and other principal cities*

CMP

A Million Dollars in Custom Molding Facilities to Guarantee "Your Blueprint in Plastic"... with Savings!



● Magnetic Perforating Die set-up in small inclinable punch press.

Magnetic PERFORATING DIES

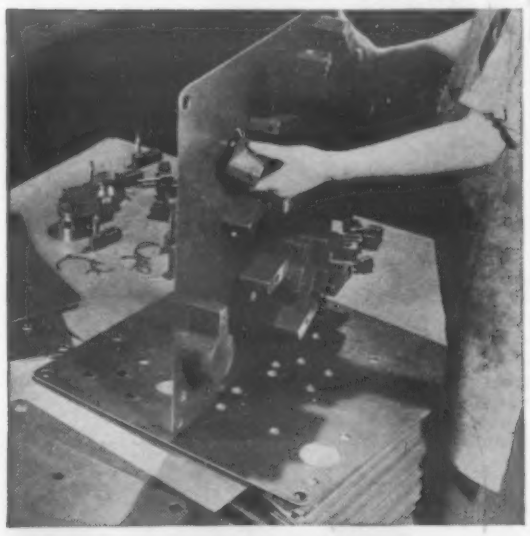
NEW and FAST Method for perforating Sheet Metal

SAVE PRESS DOWN TIME. Approximately 15 minutes required to change from punching one subject of say 20 holes to a different 20 hole arrangement. Whistler Magnetic Perforating Dies *increase* press production.

HOLD CLOSE TOLERANCES. Hole centers may be held to .0005" accuracy or as close as can be jig bored.

GREATER PUNCH AND DIE LIFE. Concentricity of punch and die assured thus giving uniform clearance around punch, increasing punch and die life.

SAVE FLOOR SPACE. Die storage cut to a minimum because only the 2 locating templets are stored...all that is required to duplicate the set-up.



● Die retainers complete with bushings being inserted in die templet.

REDUCE DIE COSTS. Whistler Magnetic Perforating Punch and Die units are used repeatedly for different hole arrangements. When completing one job, remove all units from templet and put them into service on the next different set-up. Combine any number of hole sizes and shapes. Punch and die costs are amortized over continued reuse in many jobs.

Write for Catalog...

Whistler Magnetic Perforating Punches and Dies have *proven* their cost-cutting advantages in many prominent plants. The catalog shows how. Send for it today.

S. B. WHISTLER & SONS, Inc.

756 MILITARY ROAD, BUFFALO 17, NEW YORK

Also manufacturers of a complete line of drawing, forming, blanking and progressive dies to special requirements.

News Digest

continued from page 11

Frangos, Haynes Stellite Div. of Union Carbide & Carbon Corp., in his paper "Design Factors in Investment Casting."

Tolerances that can be held on investment castings vary with size and shape. Pattern material is also a factor, as greater uniformity is obtained with plastic than with wax. In general, tolerances of ±0.005 in. per in. are held, with a maximum tolerance of ±0.003 in. on dimensions of ⅜ in. or less. This rule is effective up to 2 or 3 in., although proportionately closer limits are frequently held on larger dimensions. Machining tolerances should not be expected.

Undercuts or negative angles are undesirable from a cost standpoint but, if necessary, they can usually be incorporated by use of special cores. Small holes can be cast in thin sections, but blind holes are more difficult and sometimes impractical. If a machinable alloy is being used and close limits on a hole are desired, it is advisable to include stock in the casting for subsequent drilling and reaming operations.

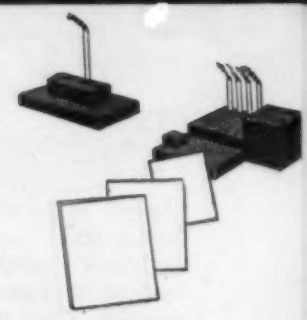
Despite some process limitations, there are designs which cannot be made at a practical cost except as investment castings. As process refinements are introduced, the author pointed out, it is becoming possible to offer attractive prices on an increasing number of applications.

Cold Roll Forming

In a paper entitled "Cold Roll Forming of Metals," E. J. Vanderploeg, The Yoder Co., discussed the advantages and limitations of that process in which a flat strip of metal is progressively formed into the desired shape.

When roll forming is not to be followed by other fabricating operations, it is common practice to use stock which already has the final finish. The roll pressures used in forming light gages of metal are low enough to permit forming of galvanized, electro-galvanized and electroplated stock. Metals which have been buffed, polished or burnished can also be roll-formed without objectionable marring of the surface.

(Continued on page 126)



MANUFACTURERS' LITERATURE

Materials

Iron • Steel

Heat Resistant Stainless Steels. Armco Steel Corp., 12 pages, illustrated. How to select stainless steel for a heat resisting application. Compares graphically strength and oxidation resistant characteristics of the various types. (1)

Workable Stainless Steel. Carpenter Steel Co., 5 pages. Extensive information on properties, uses and workability of Carpenter Stainless No. 10. Because it work-hardens more slowly than other chromium-nickel grades, it is suitable for parts requiring severe cold heading or upsetting such as nuts, bolts, etc. (2)

Steel Design. Climax Molybdenum Co., 72 pages. Reviewed previously. Booklet entitled "3 Keys to Satisfaction" tells how to combine good design, high quality steel and proper treatment for best results. (3)

Induction Hardened Bar Steel. Jones & Laughlin Steel Corp., 8 pages, illustrated, No. AD-99. Reviewed previously. Principal advantages of Electreat cold finished steel bars, heat treated by induction coils. Charts show hardenability and mechanical properties. (4)

Nonferrous Metals

Magnesium. Dow Chemical Co., 8 pages, illustrated, *Magnesium Topics,* Vol. 1, No. 1. Articles on extrusion of powdered magnesium alloys and sand casting magnesium. (5)

Metal Powders. Metals Disintegrating Co., Inc., 4 pages. Lists metal powders, pigments and abrasives supplied by this company. Describes facilities for providing unusual alloy powders and quick delivery service. (6)

Precious Metal Alloys. J. M. Ney Co., 4 pages, illustrated. Describes properties of Paliney No. 7, a high palladium-low gold alloy, and its application to sliding electrical contacts. Test data shown. (7)

Nonmetallic Materials

Thermoplastic. American Molding Powder & Chemical Co., 4 pages, illustrated. Advantages of Ampacet cellulose acetate, a thermoplastic molding powder made in grades for injection and extrusion molding and in all colors. Properties chart included. (8)

Nylon Textile Fibers. Nylon Div., E. I. du Pont de Nemours & Co. (Inc.), 36 pages, No. A-7597. Reviewed previously. Complete data on properties of nylon textile fibers and their numerous and varied industrial applications. (9)

Laminating Material. Flexfirm Products, 4 pages. Characteristics of Dryply low-pressure laminating material, consisting of glass cloth or mat impregnated with a polyester type resin, to which catalyst has been added. (10)

Plastic. M. W. Kellogg Co., 5 pages, illustrated, No. 1-12-49. Complete description of properties of Kel-F, a high-temperature, non-inflammable thermoplastic with good electrical resistance, moisture resistance and good fabricating characteristics. (11)

Alkyd Molding Compound. Plaskon Div., Libbey-Owens-Ford Glass Co., 6 pages, illustrated, No. 7131. Mechanical, electrical and chemical properties, plus molding characteristics of Plaskon Alkyd fast-molding compound. Case history data included. (12)

Acrylic Plastic Powders. Rohm & Haas Co., 16 pages, illustrated. Covers complete series of heat resistant, medium flow and general purpose acrylic plastic molding powders. Detailed properties given and many end products pictured. (13)

Synthetic Composition. U. S. Rubber Co., 8 pages, illustrated. Principal features and general specifications of Royalite, a tough synthetic composition. Fabricating information and typical uses included. (14)

Refractory. Western Gold & Platinum Works, 2 pages, illustrated, No. 224. Lists characteristics of Wesgo Super Refractory, said to have greater resistance to thermal shock than any other ceramic material. Also, specifications for furnace boats and flat slabs. (15)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on page 123.

Parts • Forms

Precision Production Parts. Accurate Bushing Co., illustrated. Folder describes this company's facilities for manufacturing and delivering precision parts, including sleeves, guide pins and wear resistant bushings. (16)

Aluminum Extruded Shapes. Aluminum Co. of America. Booklet explains design potentialities of the versatile extrusion process for aluminum. How use of aluminum extruded shapes can save money in fabrication and assembly operations. (17)

Precision Castings. Microcast Div., Austenal Laboratories, Inc., 16 pages, illustrated. Large variety of applications for Microcast precision castings pictured and described. Process advantages and design factors discussed. (18)

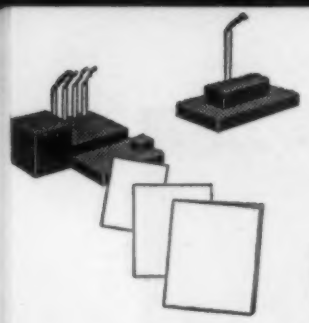
Glass Fiber Sleeving. Bentley, Harris Manufacturing Co., 4 pages. Describes new Fiberglas tubing and sleeving with high physical and dielectric properties, available at a price comparable to that of ordinary insulations. Samples included. (19)

Plastic Tubing. Carter Products Corp., 4 pages, illustrated. Characteristics and specifications of six different types of plastic tubing and pipe, which feature light weight and corrosion resistance. (20)

Plastic and Metal Parts. Central Die Casting & Manufacturing Co., 4 pages, illustrated. Describes this company's facilities for producing injection-molded plastic parts as well as zinc and aluminum die castings. (21)

Powdered Metal Parts. Chicago Powdered Metal Products Co., 4 pages, illustrated. Advantages of Camet custom-molded powdered metal parts. Also lists standard materials used and gives tips on designing. (22)

Threaded Parts. The Cleveland Cap Screw Co., 4 pages, illustrated. Describes this company's upset process for making headed and threaded parts of high quality at low cost. (23)



MANUFACTURERS' LITERATURE

Cold Headed Parts. Continental Screw Co., illustrated. Folder explains how to design and specify cold headed fasteners and parts. Advantages of cold heading process discussed. (24)

Stainless Welding Fittings. Cooper Alloy Foundry Co., 8 pages, No. 52W. Latest prices of stainless steel welding fittings, including elbows, return bends, stub ends, tees, etc., in types 304, 316 and 317. (25)

Coil Springs, Wire Parts. The Cuyahoga Spring Co., 20 pages, illustrated, No. 49. Shows typical springs and wire forms up to ½-in. dia. manufactured by this company from all wire materials. Includes information on how to order and specify these forms. (26)

Stampings, Assemblies. Detroit Stamping Co., 4 pages, illustrated. Shows variety of typical parts produced as metal stampings by this company. Pressed metal assemblies also produced. (27)

Glass Tubing. Fischer & Porter Co., 8 pages, illustrated, No. 95. Shows variety of precision-bore Glo-Tech glass specialties made from round, square and capillary tubing. (28)

Stampings, Assemblies. Hunter Spring Co., 4 pages, illustrated, No. 601-A. Describes this company's facilities for producing stampings and assemblies, and pictures a variety of representative parts. (29)

Custom-Molded Plastics Parts. Imperial Molded Products Corp., 12 pages, illustrated, No. 300. Information on this company's custom molding service. Properties of main plastics groups compared and typical parts shown. (30)

Die Castings. Litemetal DiCast, Inc., 12 pages, illustrated. Reviewed previously. How to select best light metal alloy for die casting. Shows this company's facilities for producing aluminum and magnesium pressure die castings. (31)

Gray Iron Castings. Meehanite Metal Corp., 8 pages, illustrated, No. 31. Reviewed previously. One of a series of application and engineering data booklets on casting. Shows specific applications for Meehanite gray iron castings. (32)

Cast Shapes. Motors & Metals, Inc., 4 pages, illustrated. Shows line of Meehanite standard shapes and forms from which many small- and medium-sized parts can be quickly produced with elimination of pattern costs. (33)

Brass and Bronze Forgings. Mueller Brass Co., 8 pages, illustrated, No. H58318. Advantages offered by this company's brass and bronze forged parts. Pictures variety of typical forgings. (34)

Metal Powder Parts. Plastic Metals Div., National Radiator Co., 4 pages, illustrated, No. 567. Reviewed previously. Describes some of the more important applications for this company's iron, steel, nickel, manganese and silicon powders. (35)

Powder Metallurgy. New Jersey Zinc. Co., *Horse Head Bulletin,* March 1950. Brief articles on designing for powder metallurgy, plus die casting, ore prospecting and television receivers. (36)

Plastic and Rubber Parts. Ohio Rubber Co., 4 pages, illustrated. Information on this company's facilities for producing plastic or rubber parts. General information on thermoplastics included. (37)

Precision Stampings. Patton-MacGuyer Co., illustrated. Folder describes small metal stampings produced by this company on order. (38)

Plastics Parts. Regal Plastic Co., 8 pages, illustrated. Shows variety of typical parts engineered and produced by this company. (39)

Heat Exchanger Tubes. Republic Steel Corp., Steel & Tubes Div., 20 pages, illustrated, No. BT-D-20M. Advantages and applications of Electrunite boiler, heat exchanger and condenser tubes. Method of manufacture and control described. Specification data included. (40)

Hose, Molded Parts. Resistoflex Corp., 4 pages, illustrated, No. 4g/3. Reviewed previously. Properties and uses of resinous-lined, reinforced industrial hose and custom-built molded parts produced by this company. (41)

Aluminum Roll-Formed Shapes. Reynolds Metals Co., Industrial Parts Div., No. 44-01. Reviewed previously. Catalog of aluminum roll-formed shapes, produced on order. Includes dimensional drawings and describes formability characteristics of these shapes. (42)

Inorganic Plastic Moldings. Rostone Corp., 6 pages, illustrated, No. 100. Reviewed previously. Data on general characteristics of Rosite inorganic plastic moldings. Recommends moldings for various electrical insulation purposes. (43)

Metal Powder Machine Parts. The Wel-Met Co., 4 pages, illustrated, No. 103. Reviewed previously. Case histories for 25 different machine parts fabricated by this company from metal powders. Gives material, former fabrication method and advantages gained by change. (44)

Industrial Screens. Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., 76 pages, illustrated, No. 1249. Extensive catalog of wire cloth and screens. How to order these forms. Various types discussed with reference to specific applications. (45)

Coatings • Finishes

Graphite Coatings. Acheson Colloids Co 4 pages, illustrated, No. 431. Characteris of Dag colloidal graphite which enable to impart lubrication properties, electr conductivity, heat absorption or pigmen tion to porous materials. (4

Phosphate Coatings. American Chemi Paint Co. Chart lists 24 different phosph coating processes for metals. Gives types metals treated, product used, method of a plication, typical parts treated, bath con tions, etc. (4

Surface Coating Resins. American Cyanam Co. Guide lists properties, compatibil and drying schedules of alkyd, formal hyde, phenolic and dibasic acid resins f use in surface coatings. (4

Glass Coatings. Brooklyn Varnish Ma facturing Co., 1 page. Data sheet on T On Glo-Dur finishes for glass, consisting synthetic resins and pigments combined obtain adhesion, toughness, color retenti and heat resistance. (4

Anti-Corrosion Coatings. Minnesota Mini & Manufacturing Co. Folder containi samples of 28 different Coro-Gard an corrosion coatings for metals, including f base coatings and 23 top-coats. All coati are sprayable and air-drying. (5

Plastic Latex. Naugatuck Chemical Di U. S. Rubber Co., 2 pages. Data sheets o Kralastic latices 4100-A, 4101, 4102-A an 4104, which provide glossy, wear resista coatings of varying flexibility for fibro materials. (5

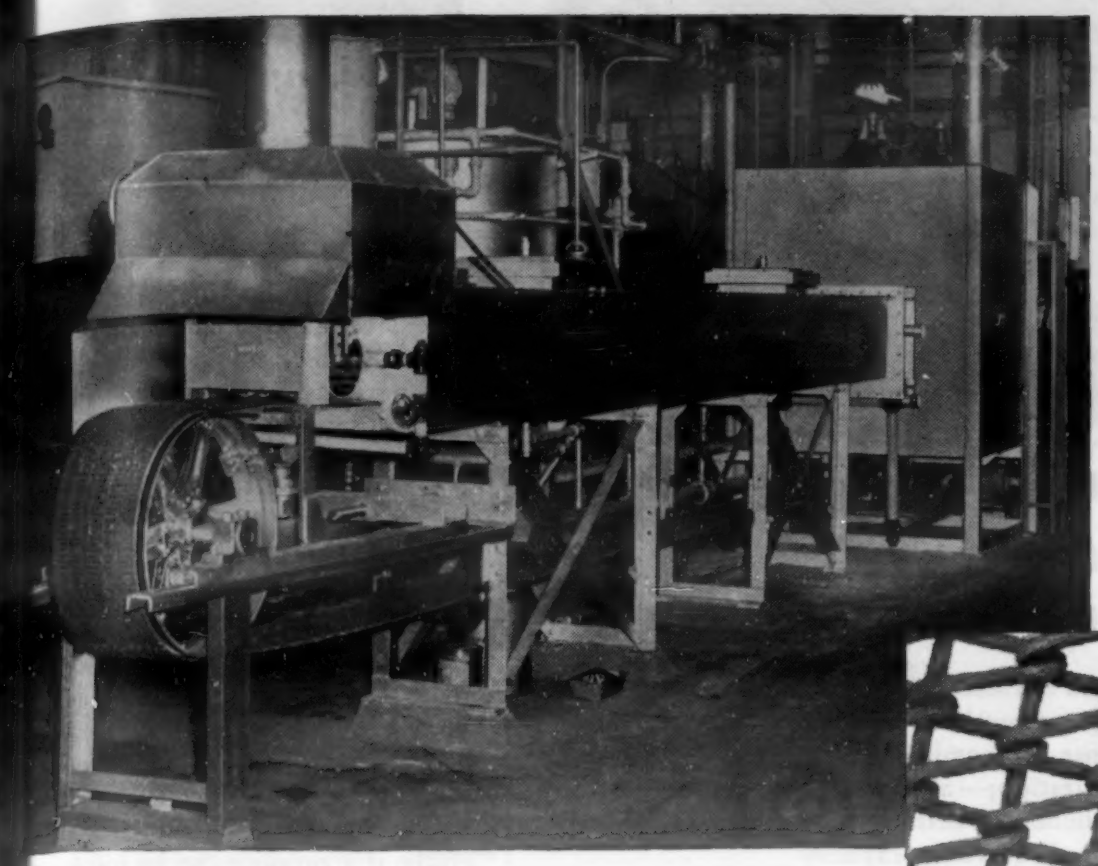
Finishes. The Sherwin-Williams Co., 1 pages, illustrated, No. B652. Describ Dimenso finish, which can be produce smooth semi-blended, subtly diffused c sharply hammered in pattern. Applicatio and equipment also discussed. (5

Methods and Equipment

Heat Treating • Heating

Controlled Atmosphere Furnaces. Delawar Tool Steel Corp., 16 pages, illustrated. De tailed description of constructional feature and principle of operation of this com pany's controlled atmosphere furnaces. (5

Sintering Furnaces. Electric Furnace Co., 4 pages, illustrated. Pictures and describe variety of furnace installations for sintering metal powder products and other processes. (5



Inconel conveyor belt installed in Electric Furnace Company continuous brazing furnace at the Beech Aircraft Corp., Wichita, Kansas. This WISSCO belt woven of Inconel was manufactured by the Wickwire Spencer Steel Division of the Colorado Fuel and Iron Corporation. It has served for two and a half years, operating at temperatures as high as 2040° F.

Close-up photograph of the woven Inconel conveyor belt after 22,368 hours of operation in high-temperatures brazing operations. Note that the belt is still in excellent condition.

Read this amazing service story!

BRAZING BELT STILL GOOD AFTER 22,368 HOURS AT 1300° TO 2040° F.

TWO AND A HALF YEARS AGO, the Beech Aircraft Corporation installed an Electric Furnace Company brazing furnace, equipped with a Wickwire Wissco conveyor belt of Inconel*.

For 22,368 consecutive hours, this Inconel belt carried parts through the brazing furnace ... 22,368 hours of operation at temperatures from 1300° to 2040° F!

This truly amazing record was made possible by Inconel's high-temperature properties. Inconel withstands extreme temperatures and high-temperature corrosives. It is strong, tough, hard, yet ductile enough to be readily workable. And it is highly resistant to both stress and vibration fatigue.

Welded joints in Inconel are as corrosion- and heat-resistant as the alloy itself. This ... and Inconel's availability in a variety of standard mill forms ... makes Inconel a logical material for fabricated fixtures and equipment.

For these reasons, Inconel has long been the first choice of many leading fabricators of heat-treating equipment. Consequently, you'll find it easy to buy fixtures of popular design ... racks, trays, baskets, retorts. The same experienced fabricators will quote on equipment of your own design, too.

For further information about Inconel ... and help with your high-temperature corrosion and fabrication problems ... write directly to Inco.

*Reg. U. S. Pat. Off.

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THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

INCONEL* ... *for long life at high temperatures*

• *EF Special Atmosphere Roller Hearth Furnace Continuously Bright Normalizing Two Strands of 27" Strip — Capacity 7200 Lbs. Per Hour.*

ANNEALING STRIP STEEL
Continuously
IMPROVES THE DRAWING QUALITIES

• **EF continuous annealing and normalizing furnaces subject the entire length, and width of the strip to *exactly the same* time and temperature treatment, resulting in extreme uniformity of grain size, yield point, and completeness of recrystallization;— all definite advantages for deep drawing. They tie-up a minimum of material in process; — usually *cost less* than batch equipment of equivalent capacity.**

Capacities to 28,000 lbs., or more, per hour — single or multiple strands to 54", or wider. Send today for complete details.

THE ELECTRIC FURNACE CO.
GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION *Salem - Ohio*

THIS IS LOW COST WELDING!

When a touch on a button moves weldments like these into the correct, most convenient position for a downhand pass, you get more arc time, more welding at lower cost. C-F power operated Positioners rotate the work in a full circle at any point in a range of 135° from the horizontal—giving welders a choice of an infinite number of downhand welding positions instantly.

Every requirement for faster, better positioned welding—constant or variable speed table rotation, full 135° tilt, self-locking gearing which holds the table in any position, oversize built-in main tilt and rotating bearings, choice of two base styles, and many other features—are built into C-F Positioners.

C-F Positioners are available in Hand or Power operated models, and are made in capacities up to 30,000 lbs. and larger.

Write for the new C-F Positioner Catalog.

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CULLEN-FRIESTEDT CO., CHICAGO 23, ILL.

C-F positioned welds mean better, more economical welds

News Digest

Hot-dipped galvanized stock is being extensively used in cold roll forming but is subject to greater limitations. Ordinary paint, enamel and other organic finishes are not well adapted to this process, but improved organic coatings have been developed in recent years.

Cold roll forming is applicable mainly in the mass production of shapes of uniform profile. An important advantage of the process is the reduction in weight often obtained by forming a flat strip of metal into box, channel, tubular and other hollow shapes to obtain the highest possible strength-weight ratio. Generally, if a product can be roll formed or redesigned for roll forming, the result will be lower unit cost.

Minimum practical radius of bend is equal to the thickness of the stock but it should preferably be double the stock thickness or better. However, sharp inside and outside corners can be obtained at some sacrifice in strength. Maximum thickness of stock suitable for forming depends upon the material used and on the angle or radius of bends or curves. Plain angles, channels and other members up to ½ in. thick are being produced, as is pipe up to ¾-in. wall thickness.

Ceramic Thickness Gage Measures Coatings on Nonmagnetic Alloys

An electronic gage for measuring the thickness of ceramic coatings on nonmagnetic metals is described in Technical Report 1442, issued by the National Bureau of Standards.

Developed by Charles C. Gordon and Joseph C. Richmond in research sponsored by the National Advisory Committee for Aeronautics, the instrument provides a simple, nondestructive measurement. The new gage can be used with nonmagnetic high-temperature alloys to which magnetic thickness gages are not applicable.

The instrument consists essentially of a small probe coil, an inductance indicating system, and a device for positioning the coil and measuring its distance from the test surface. The measurement is based upon the change in inductance of the probe coil due to the proximity of the coated metal surface. Before a thick-

News about **UNICHROME** Trade Mark

COATINGS for METALS

New Plastic Coating Compounds

DEFY HARD, CORROSIVE SERVICE!

. . . provide tough, thick coatings that have elasticity and high chemical resistance

GGESTED USES: Parts and surfaces quipment exposed to strong chemical ck.

ichrome "4000 Series" Compounds, group of vinyl-base liquids and tes, are easily applied to metals. en baked into solid form, the que combination of properties of se plastisols and organosols as- es long service under severest ditions.

Often, Unichrome "4000 Series" mpounds will enable you to use tter or less costly metals for parts uiring resistance to many of the ngest corrosives. Mineral acids me up to 50% concentration) for mple. Also oils, alkalies, salts, ter. Even such active oxidants as omic acid. The coatings do not taminate.

Cured compounds have good ten- strength – resist abrasion and "bumping." Important, too, is their *workability*. Spraying or dipping gives you a coating from .003" to 3/16", depending on method of application, with only one application.

One more point. The physical properties of these compounds can be modified from soft and elastic to relatively hard and rigid. So if you want a coating compound to meet *your* specifications – on corrosion resistance, on resilience, on method of application – contact headquarters for "Coatings for Metals." Tell us your requirements.

UNICHROME Trade Mark

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Detroit 20, Mich. • Waterbury 90, Conn.
Chicago 4, Ill. • Los Angeles 13, Cal.
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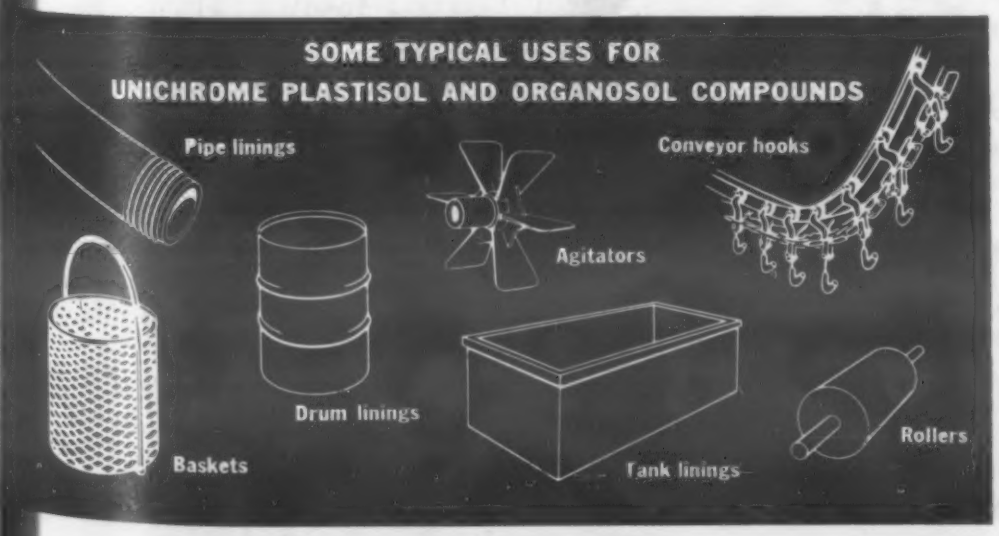
United Chromium Limited, Toronto, Ont.



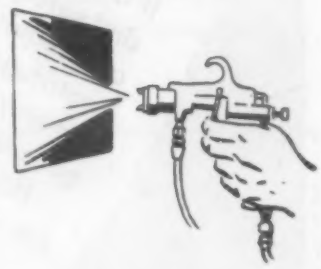
For a zinc finish that stays bright

Because it gives zinc plate a brilliant lustre, protects it from corrosion, and costs so little, Unichrome Dip Finish is being used extensively on refrigerator shelves today...as well as on other wire goods, die castings, screws, nuts, bolts.

New primer for magnesium and aluminum

Hard-to-coat metals such as magnesium and aluminum get a finish that really sticks when coated with Unichrome Primer AP-10. Not only does this organic primer promote adhesion, but it also provides extra corrosion-resistance and increases durability of top coats used.

Yes . . . a HARD finish can also be FLEXIBLE



Unichrome Coating B-115 is an exceptionally clear, baking synthetic finish that can be used on strip and sheet prior to fabrication. For in addition to adhering despite flexing, and forming operations, it also has the hardness to resist abrasion.

DURASPUN

Gas Generator Tube...

30% Cr — 20% Ni

This tube is made up of three centrifugally cast sections, each about 9 feet long and welded together to make a total length of some 27 feet. The wall thickness is ½ inch.

Centrifugally cast alloy steel is exceptionally uniform, strong and close-grained. More and more it is being used for process work where high strength and safety coupled with heat or corrosion resistance are required. And a big share of the industry's centrifugal casting tonnage is coming from the same Duraloy high alloy foundry that produced this gas generator tube.

How about making Duraloy your source of supply for chrome iron, chrome nickel or nickel chrome castings — centrifugal or static? We have the experience.

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News Digest

ness measurement is made, the
strument is calibrated on an uncoa
specimen identical in size, shape a
composition with the coated specim
to be tested.

The gage is designed to meas
coatings up to 0.090 in. thick.
thin coatings, where the coil is wi
in 0.020 in. of the metal surface,
thickness indicated is correct to wi

*This new gage measures thickness of n
conducting coatings on nonmagnetic me*

in about 0.0002 in. When the coi
0.10 in. from the metal surface, ha
ever, readings may be as much
0.001 in. off.

Certain metals which are the
selves nonmagnetic or only wea
magnetic produce magnetic sca
when oxidized. Presence of any m
netic material in the coating or
the coating-metal interface makes
curate measurements impossible.

Annealing Removes Embrittlemen From Welded Chromium Stainles

Unexpected embrittlement h
been encountered in several weld
chromium stainless steels; a meth
of remedying this difficulty by po
annealing was described by Helm
Thielsch in the *Welding Jour*
(Mar. 1950).

The author found that wa
quenching or air cooling Types 40
modified 410 (less than 0.08% c
bon) and 430 stainless steels fro
temperatures above 2200 to 2300
will produce in them a rather abru
embrittlement and increase in ha
ness. Such temperatures are encou
ered in the heat-affected zone duri
welding.

Although embrittlement seems
accompany severe grain growth, ha
grain size alone does not account f
the phenomenon. Nor do hardn
values alone give a true indication

If you want results like this...

use

DIVERSEY No. 909

Unique Heavy Duty Soak Tank Cleaner

WITH

DIVERSEY EVERITE

Rust and Heat-Scale Remover

Gears courtesy of
Gear Specialties, Inc.
Chicago, Ill.

Steel Gears—Case History

PROBLEM: To remove oil, greases and shop dirt from gears prior to heat treatment and to descale the gears after heat treatment without hydrogen embrittlement and with a minimum of dimensional change. Complete de-rusting of various iron and steel shapes also had to be considered.

PREVIOUS PROCESS: A highly caustic cleaner for the removal of oils and greases. Raw acid for general rust and scale removal. Wire brushing for the removal of heat scale and discoloration from gears susceptible to hydrogen embrittlement and whose dimensional tolerances were very small.

PRESENT PROCESS: Diversey No. 909 for oil and grease removal and Diversey Everite for all descaling and de-rusting operations.

RESULTS: Diversey No. 909 produced decidedly cleaner surfaces than the previously used material and did it in less time! The heat treated work contained no burned oil residues.

The gears which could not be pickled previously due to tendencies for hydrogen embrittlement are safely descaled with Diversey Everite. Wire brushing operations have been eliminated. No attack occurs on the gears in spite of the fact that prolonged pickling is required to remove the heavy scale at the root of the gear teeth. And Everite produces brighter surfaces than were previously obtainable with any method.

MAIL THIS COUPON FOR COMPLETE INFORMATION

THE DIVERSEY CORPORATION
Metal Industries Department
1820 Roscoe Street • Chicago 13, Illinois
In Canada: **The Diversey Corporation (Canada) Limited**
100 Adelaide Street West, Toronto, Ontario

THE DIVERSEY CORPORATION
Metal Industries Department
1820 Roscoe Street, Chicago 13, Illinois

Gentlemen:
Please send me complete information on Diversey No. 909 and Diversey Everite including New Bulletins.

Name_____ Title_____

Company_____

Address_____

City_____ State_____

DM2

how often do you dump cleaning tanks?

PQ SILICATES FOR FABRICATING METAL CLEANERS

Metso Granular
($Na_2SiO_3.5H_2O$) Sodium Metasilicate. Free-flowing, white granular product.

Metso 99
($Na_3HSiO_4.5H_2O$) Sodium Sesquisilicate. White, granular, free-flowing.

G-C
($Na_2O.2SiO_2$) Powdered Sodium Silicate. Hydrated, alkaline. Readily soluble.

G Silicate
($Na_2O.3.22SiO_2$) Hydrated powdered sodium silicate (sometimes referred to as trisilicate), rapidly soluble.

When a PQ Silicated compound is your cleaner, your tanks keep their top efficiency for long periods. PQ Silicates produce cleaning solutions of the right sustained alkalinity, which insures prolonged life.

It is the special component of PQ Silicate Cleaners, soluble silica, that maintains the pH of the solutions until all the alkali is used. Cleaning action is kept at a high pitch for a longer time. Ask for PQ Silicate Cleaners for more economical, longer lasting baths.

PHILADELPHIA QUARTZ COMPANY
1133 Public Ledger Bldg., Phila. 6, Pa.

Sodium Sesquisilicate U.S. Pat. 1948730, 2145749
Sodium Metasilicate U.S. Pat. 1898707

METSO PQ

INDUCTION HEAT
PERMITS 2 OZ. TOLERANCE

ON HIGH SPEED FORGING PRESS

It previously took 8 to 10 drops of a hammer, with slow flow of metal, to achieve close tolerances required for connecting rod forgings. But this leading automobile plant recently combined scale-free, closely controlled Ajax-Northrup heat with improved die design, and pioneered the development of rods *press-forged* at unheard-of production rates.

Clean, fast induction heat now saves tons of steel yearly in many forge shops. Increases die life as much as 20%. No abrasive scale, and accurate timing prevents overheated dies. A bank of Ajax-Northrup heaters at each machine handles several sizes of stock, heating variable lengths with quickly adjustable timing and feeding devices so that jobs can be changed in a jiffy. Saves start-up time; the first hot billet is ready in seconds. No need to "pull" stock during shut-downs—just push the "off" button instead. Working conditions are better, too.

Whether you want to improve quality or reduce costs, you'll find the right answer in Ajax-Northrup. Over 33 years experience in successful induction heating and melting.

AJAX ELECTROTHERMIC CORPORATION

AJAX PARK, TRENTON 5, N. J.

Associate Companies
THE AJAX METAL COMPANY • AJAX ELECTRIC FURNACE CORPORATION
AJAX ELECTRIC COMPANY, INC. • AJAX ENGINEERING CORPORATION

SINCE 1916

AJAX NORTHRUP
HEATING & MELTING

1195

News Digest

the other mechanical properties these stainless steels. Thus, althou two specimens of the same all quenched from different elevat temperatures, exhibited identic hardness values, the elongation w found to vary by as much as 20 (in 2 in.) and the Charpy impa values by 20 to 25 ft.-lb. Therefo acceptance of welds in these ferri steels cannot be based on hardne tests alone.

With the exception of excessi grain growth, the detrimental effe of this overheating can be remove by annealing between 1350 and 14 F. In part this can be accomplishe by depositing multibeads instead single beads. Wherever restoration the ductile properties of the steel of major importance, however, po annealing is far more effective th any change in welding technique.

Underground Corrosion of Metals Studied by Bureau of Standards

Alloys which have high resistan to corrosion under some condition do not always stand up well durin underground service. The particul problems raised by soil corrosion ha been studied at the National Bure of Standards for a number of yea and some of the conclusions reache are reported in Technical Repo 1434.

As a group, copper and its alloy with silicon, zinc and nickel a highly resistant to corrosion in soil which are extremely corrosive ordinary iron and steel. The copp alloys, however, differed rather wide in corrosion resistance, depending o environmental conditions. For exam ple, in soils high in sulfides, copp corroded at an appreciable rate, bu low-copper brasses were quite resi tant. Low-copper brasses showed goo resistance to corrosion as manifeste by reduction in thickness and by th development of deep pits, but thi advantage was offset by their suscep tibility to dezincification. This typ of corrosion can be prevented by small arsenic addition.

Small amounts of chromium, nick and molybdenum, which produc high resistance to atmospheric co rosion in high-strength steels, wer

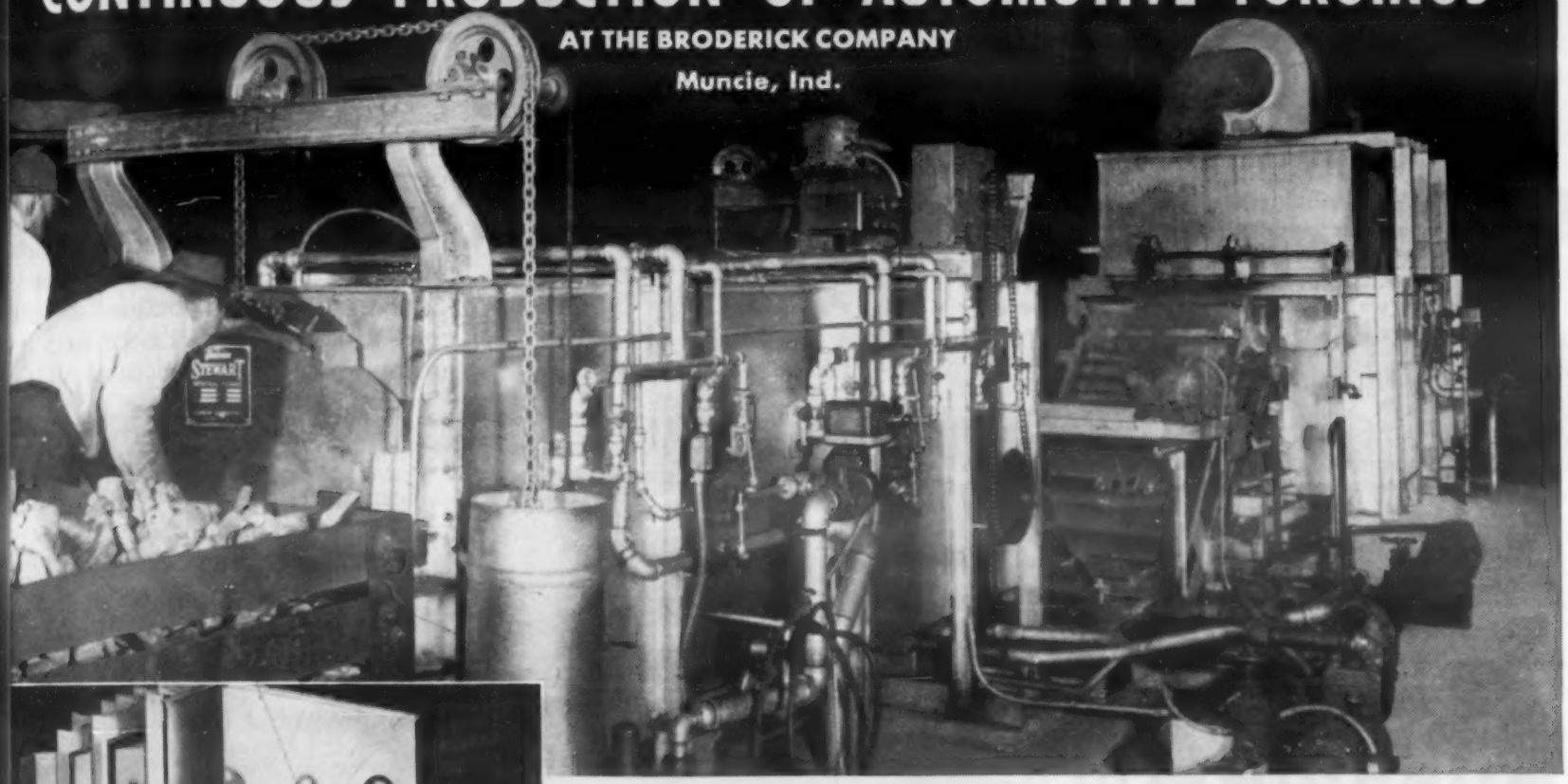
No. 100 of a Series of Typical Installations

Sunbeam
STEWART
THE BEST INDUSTRIAL FURNACES MADE

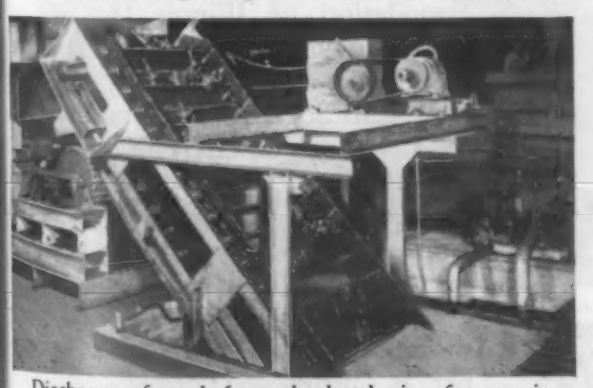
Installations like these show how Sunbeam Stewart furnaces are helping manufacturers reduce cost and keep themselves competitive

CONTINUOUS PRODUCTION OF AUTOMOTIVE FORGINGS

AT THE BRODERICK COMPANY
Muncie, Ind.



Separate combustion chambers are employed in the Sunbeam Stewart Recirculating Draw furnace. combustion being completed within the chambers.



Discharge of work from the hardening furnace is handled by an alloy chute enclosed within the furnace. A manually controlled skid plate can be positioned for discharging onto a table outside the furnace for material requiring air quenching or normalizing.

About 1300 lbs. of forgings per hour are processed in this Sunbeam Stewart Harden, Quench and Draw unit by the Broderick Company. These pieces vary in weight from 4 to 7 lbs. The Hardening furnace has a usable heating space of 30″ wide by 10′ long.

This is No. 100 in a series of typical installations demonstrating the wide variety of specific requirements in the metal-working industry Sunbeam Stewart furnaces are designed to meet.

Broderick's forgings, heat treated to customers' specifications, involve close hardness tolerances. The Sunbeam Stewart installation gives them accurate automatic control of the hardening, quenching and drawing operation throughout the continuous heat treating cycle.

A continuous flat surface throughout the entire heating chamber of the hardening furnace minimizes distortion. This furnace can also be used for normalizing, annealing, etc. by turning a manual control which positions an alloy skid plate at the discharge to let the work drop onto a table.

The forgings are drawn in a Sunbeam Stewart continuous recirculating-type furnace. Two zones of control are employed, each equipped with its own proportioning type controller, combustion chamber and burner equipment.

It will pay to consult Sunbeam Stewart on your heat treating problems. In addition to continuous conveyor units, Sunbeam Stewart builds a full line of standard furnaces and galvanizing equipment, gas or oil fired, electrically heated.

Sunbeam STEWART INDUSTRIAL FURNACE DIVISION of Sunbeam CORPORATION
(Formerly CHICAGO FLEXIBLE SHAFT CO.)

Main Office: Dept. 111, 4433 Ogden Ave., Chicago 23 — New York Office: 322 W. 48th St., New York 19 — Detroit Office: 3049 E. Grand Blvd., Detroit
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A letter, wire or 'phone call will promptly bring you information and details on SUNBEAM STEWART furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a SUNBEAM STEWART engineer will be glad to call and discuss your heat treating problems with you.

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WROT WASHERS

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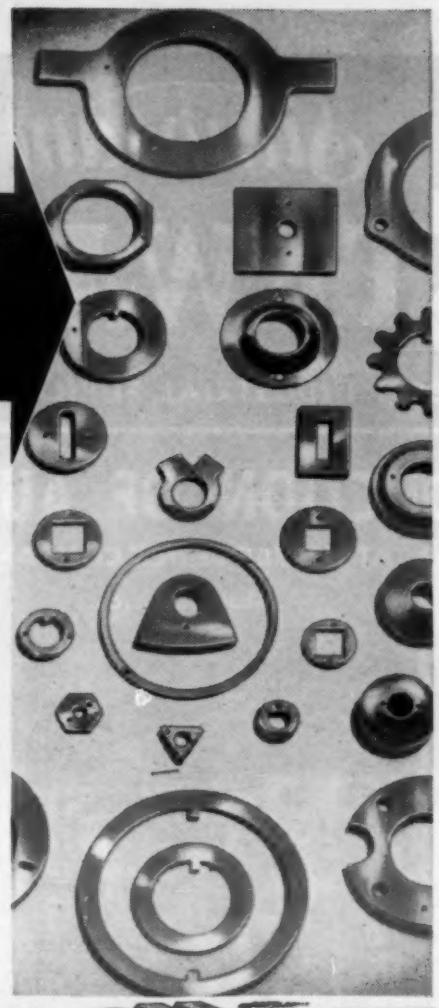
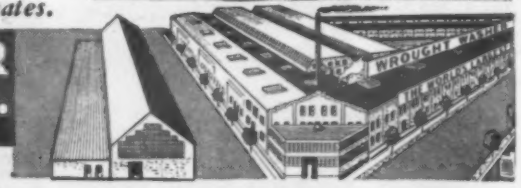
Large volume production, the most advanced methods and facilities, plus more than 60 years of continuous experience in the manufacture of Washers, are factors that enable us to offer you top quality washers and stampings at competitive costs. Over 22,000 sets of dies for making Washers of every type (Standard and Special), from every type of material, for every purpose, in any finish. STAMPINGS of all descriptions; Blanking, Forming, Drawing. *Submit your blueprints and quantity requirements for estimates.*





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The World's Largest Producer of Washers

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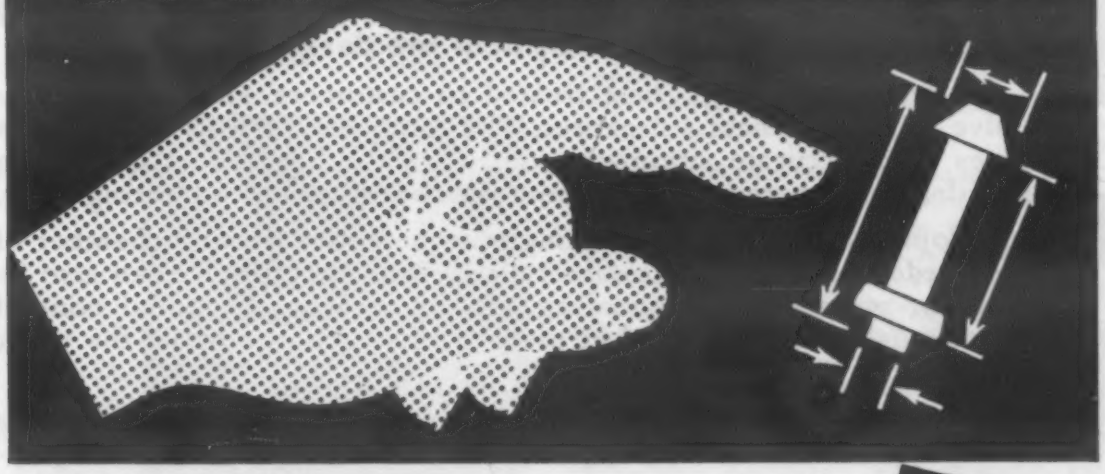

Hassall cold-headed fasteners can improve your products and save you money, even on short runs. Send us your specifications for your nails, rivets and screws . . . in diameters from 1/32" to 3/8" . . . lengths up to 7" . . . in any workable metal . . . in practically any finish. Your inquiry will be handled promptly. Ask for free catalog.

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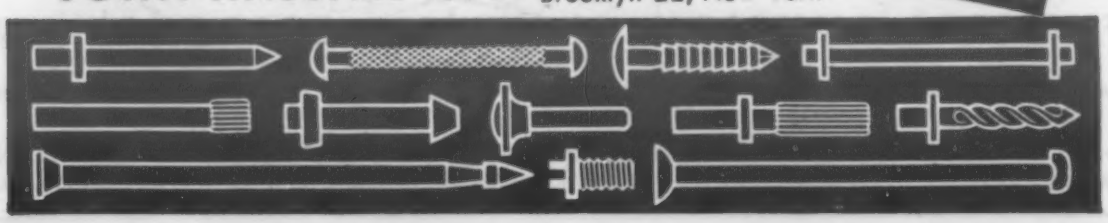

News Digest

found to contribute little to their corrosion resistance underground. This difference in behavior is attributed to soil conditions which do not favor formation of the tight, adherent rust deposits which protect against further corrosion.

A number of alloys were found to give long service underground provided reasonable allowance is made for reduction in wall thickness by corrosion. Certain steels containing high percentages of chromium and nickel showed no appreciable weight loss after the maximum exposure period. But results obtained on small test specimens are not necessarily applicable to large structures of the same material.

In certain soils where the corrosion rate of a metal rapidly diminishes, it is sometimes possible to secure infinite life for piping by increasing wall thickness. Unless a substantial increase in useful life can be obtained, however, the cost of the extra thickness would not be justified and some other means of combatting corrosion would be indicated.

Metals Research Seen Increasing

Although the metals industry as a whole has not taken advantage of the entire possibilities of industrial research, the current period is one of rapid increase in metals research, according to William E. Mahin, director of research at the Armour Research Foundation of Illinois Institute of Technology. He spoke at a recent meeting of the Denver chapter of the American Society for Metals.

"The best design engineers have on the drawing board new jet aircraft, electric generators, automobiles and even Pullman cars, for which the need of improved materials is great," he said. "And the growing shortage of certain ores, such as copper, is causing the copper companies to think of new products such as titanium."

In general, Mahin said, "engineers and researchers in practically every field of science will be turning more and more to the metallurgist, seeking answers to their problems of lighter weight, stronger, more corrosion and heat resistant alloys to make possible the creation of their particular brain children."

Inclusion-free high-carbon ferro chromium

assured by new process

MOST ball and roller bearings must take terrific punishment in service, and their dependability is based directly upon the quality of steel from which they are made.

To meet the requirements of the bearing manufacturer and his customers, the steelmaker can rely upon our newly improved ferro chromium to help him produce consistently high grade bearing steels.

The high-carbon ferro chromium we have recently developed is exceptionally free from non-metallic inclusions, entrapped slag and dissolved gases. It is made by a new process* which includes filtering out harmful inclusions by pouring the metal, as tapped from the furnace, through a layer of molten slag of special composition. In addition to removing the undesirable inclusions, this process also assures greater density of the metal and the absence of shrinkage cavities in individual lumps.

High-carbon ferro chromium contains 66 to 70 per cent chromium, 4 to 6 per cent carbon, and 3 per cent maximum silicon.

Our technical staff will be glad to demonstrate to you the benefits to be gained in your steelmaking by the use of this improved high-carbon ferro chromium. *Patented

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No industry melting *commensurate tonnage** of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field — less than 1% — with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

* *Upwards of 5 billion pounds annually.*

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ASSOCIATE COMPANIES: AJAX METAL COMPANY, *Non-Ferrous Ingot Metals and Alloys for Foundry Use*
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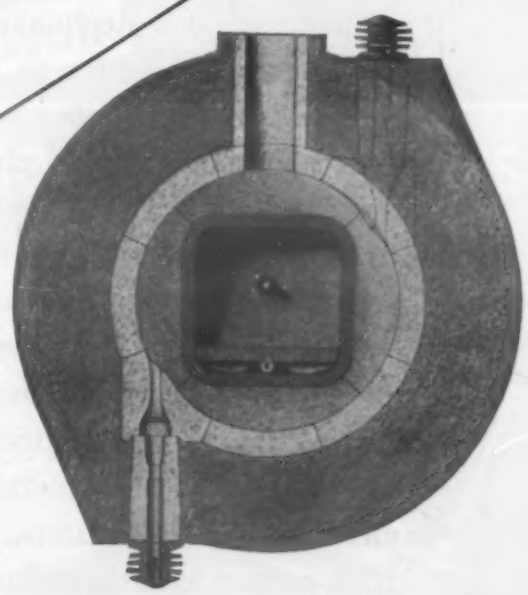
AJAX ENGINEERING CORPORATION, *Ajax-Yuno-Wyatt Aluminum Melting Induction Furnaces*

THE INSIDE STORY!



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Range, 1200° - 2800° F.

The complete story of the tangential firing principle and other distinctive features of the Delaware Controlled Atmosphere furnace is told in informative bulletin F-1.

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Wilmington, Del.

News Digest

Metal Powder Part Tests Described

A tentative method for acceptance tests on structural parts made from metal powders has been released as a new standard by the Metal Powder Association. Designated M.P.A. Standard 8-50 T, it describes procedures for testing a variety of pressed and sintered metal powder parts.

Tests described include chemical composition, density for oil-impregnated and non-impregnated parts, porosity, method of manufacture, dimensions and tolerances, mechanical properties and hardness. Sampling procedure is also described and drawings showing six examples of mechanical property tests are included.

This standard can be obtained for 25c a copy from the Metal Powder Association, 420 Lexington Ave., New York 17, N. Y.

Development of Lost-Wax Castings Affected by Economic Factors

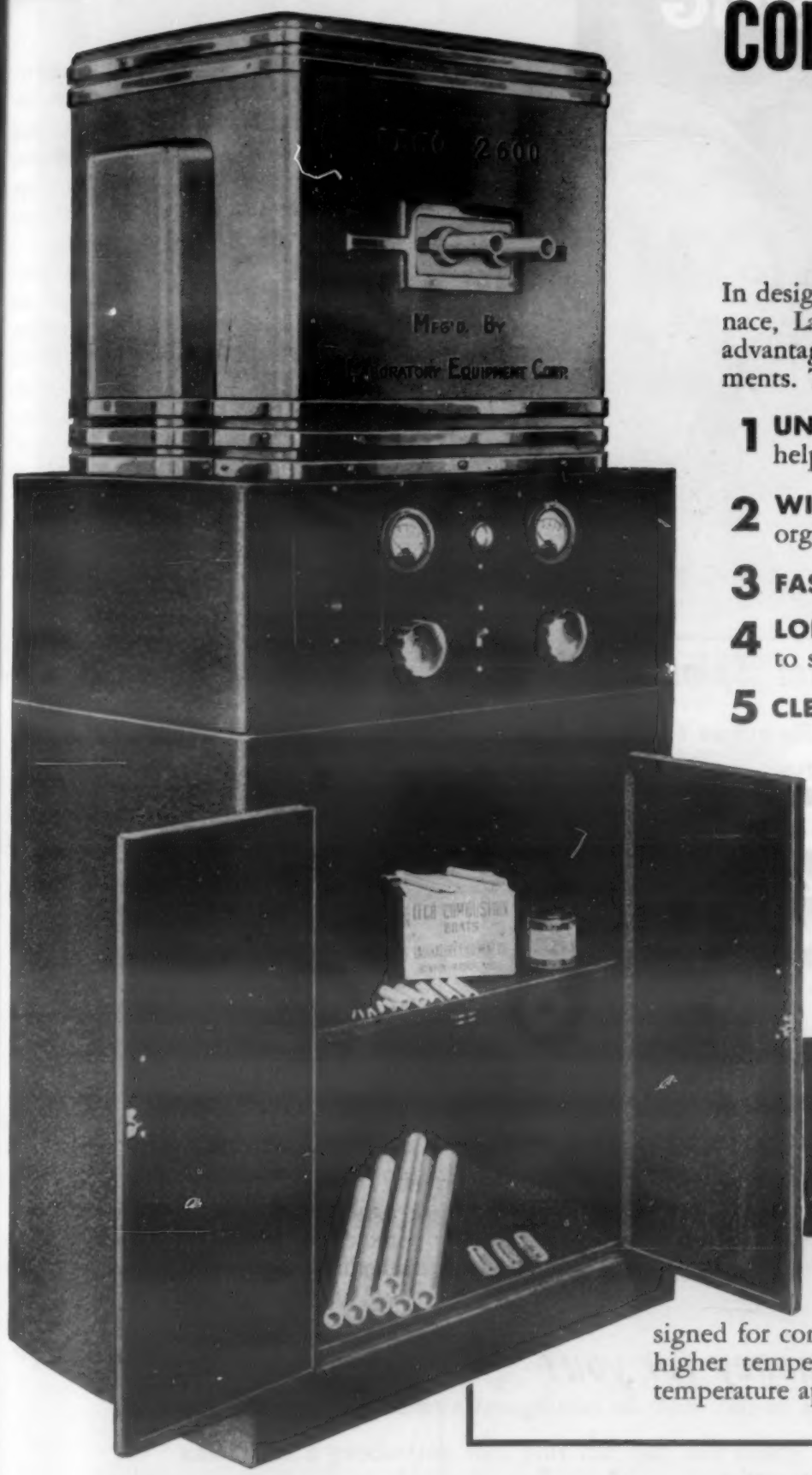
A look at the economics of the "lost-wax" process of precision casting from the British viewpoint has been provided by J. S. Turnbull in *Foundry Trade Journal* (Feb. 16, 1950).

In the "lost-wax" process, the master pattern is first made in either hard wood or metal from the design drawing, which is given an allowance for contraction. The soft-metal die is related to the master pattern by precision-casting technique, and the wax patterns are produced from it on injection machines. These patterns are invested in refractory molds, the wax is melted out, the mold baked, and the metal part is cast.

Accuracy is of primary importance since the production of cheap castings is necessarily dependent upon the reduction of scrap percentage. It has been found possible to mass-produce gas turbine blades varying in size 8⅜ to 4 in. with a scrap of less than 30%. It would not be unreasonable to expect the scrap on blades to be below 10% in two years' time.

Casting of blades is more difficult than average parts because they are not designed as castings, ratio of volume to surface area is a minimum, they combine thick and thin sections,

Advantages of GLOBAR Heating Elements complement sound Furnace Design



In designing this neat, compact and efficient combustion furnace, Laboratory Equipment Corp. makes full use of the advantages provided by GLOBAR silicon carbide heating elements. These elements meet six very necessary requirements:

1. **UNIFORM COMBUSTION TUBE TEMPERATURES**—to help maintain precise control over the material being tested.
2. **WIDE TEMPERATURE RANGE**—to handle a variety of organic and inorganic materials.
3. **FAST HEATING**—to facilitate rapid analysis.
4. **LONG AND DEPENDABLE SERVICE**—with no need to shut down the furnace when installing new elements.
5. **CLEAN OPERATION**—no noise, no dirt, no fumes.
6. **SAFE OPERATION**—no explosion or fire hazards.

Investigate the possible application of GLOBAR heating elements in your operation. For complete information on installation and operating details of these elements, write Dept. W-60 The Carborundum Company, GLOBAR Division, Niagara Falls, New York.

"LECO" 2600 COMBUSTION FURNACE

Manufactured by the Laboratory Equipment Corp., St. Joseph, Michigan, this furnace is designed for continuous duty at 2600°F and for short periods at higher temperatures. Other models are available for lower temperature applications.

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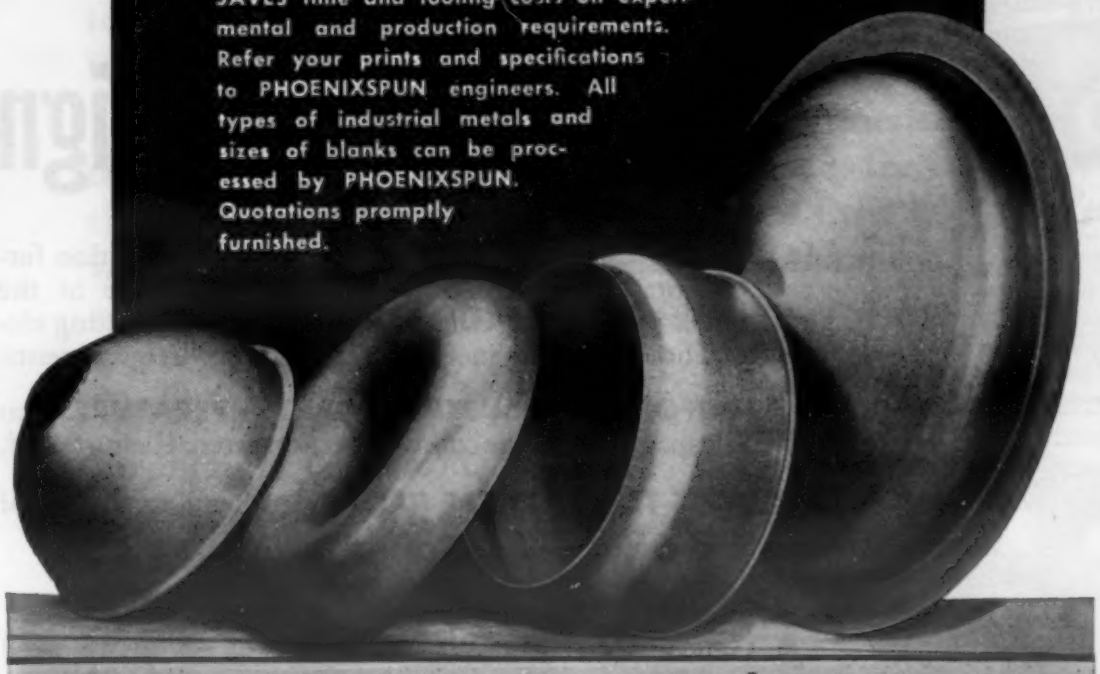
SAVES time and tooling costs on experimental and production requirements. Refer your prints and specifications to PHOENIXSPUN engineers. All types of industrial metals and sizes of blanks can be processed by PHOENIXSPUN. Quotations promptly furnished.



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News Digest

and the metallurgical soundness required on radiograph and crack detection is high. On castings other than turbine blades, scrap approximates 20%. Present cost under development conditions amounts to $4.50 per lb. for steel castings.

Although the cost of "lost-wax" castings appears to be high, the author believes process simplification, through mechanization and motion study, will have a great effect in reducing costs. Thus, it is not inconceivable that the cost of "lost-wax" steel castings will have dropped to $1.50 within the next five years.

New Product Uses Wood-Waste

A new process for making low-cost three-ply wood panels from wood-waste has been acquired by United States Plywood Corp. from an European firm. The new material, known as Novopan, is expected to be competitive to plywood in many fields.

Novopan is made by pressing wood waste into a composite board of three layers, two surface layers of wood shavings and the core material of wood chips. Good finish is effected by use of certain resins and by controlling temperature and the thickness of the shavings. The board can be made in thicknesses from 5/16 to 1¼ in. in panel sizes of 4 by 8 or 6 by 12 ft.

First plant in this country will be erected at Orangeburg, S. C., and is scheduled to be in operation by the end of the year. An initial capacity of 40 to 50 million ft. per year, based on ⅜-in. thickness, has been predicted.

News of Engineers

Warren L. Smith, senior vice president, has been elected president of the M. W. Kellogg Co., a subsidiary of Pullman, Inc. He succeeds *Harold R. Austin*, who is retiring after 47 years of service with Kellogg. Mr. Austin will continue to serve the company, however, as a consultant to

consider DIE CASTING when redesigning for LOWER COSTS

THE DIE CASTING PROCESS: Speed of production is the essence of the die casting process—the shortest distance between raw material and finished product; it is a precision, low-unit labor process, capable of producing direct from the raw material the most complex parts in nearly finished form at a single operation.

ZINC DIE CASTINGS: Zinc is the most adaptable metal for the die casting process and provides the best combination of physical and chemical properties. Zinc die castings are stable, strong, and can be cast to close tolerances; they are easily machined and a large variety of beautiful metallic and organic finishes can be readily applied to the castings.

Industry's recognition of these factors is indicated by the phenomenal growth of die casting as a production tool plus the fact that nearly 75% of all die castings by weight are made of zinc. **DIE CASTING is the Process • ZINC, the Metal • BUNKER HILL, the Preferred Zinc**

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The selection of a suitable steel and its subsequent satisfactory performance can be made easy by good design.

How and in what shape a part is made is, we hold, of fundamentally greater importance than of what it is made.

In designing a piece of machinery it is necessary to consider Design, the choice of steel, and its Heat Treatment. All three are highly significant factors, but of them we believe Design to be vital because even the best in steel and treatment will not save a poorly designed part.

To evaluate the importance of good design and its vital relationship to the selection of steel and its heat treatment, we have prepared a book—"Three Keys to Satisfaction". This starts by discussing mainly design factors involved in stress concentrations, and includes useful sketches comparing poor and good features of design from the aspect of subsequent metallurgy. It is available on request to all engineers and designers.

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MOLY

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News Digest

the president. *Bennett Archambault,* former treasurer, was named vice president and general manager, a newly created post. Other vice presidents elected were *G. Frank Bayes, Ronald B. Smith* and *Zary A. Toula.* Incumbent vice presidents Dr. *William E. Hanford, Alexander Kidd* and *Frank Liebrecht* were re-elected. *Daniel J. Olsen* was named treasurer and comptroller, and *Edwin L. Gidley* became secretary.

General Electric Co. has appointed *C. C. Clymer* manager of the Materials Handling & Testing Equipment Div. of its Industrial Engineering Divs. Mr. Clymer is replacing *M. A. deFerranti,* who was promoted to the position of assistant to the manager of the Parts Div., Aircraft Gas Turbine Divs.

Reorganization of the executive staff of Borg-Warner Corp. has just been completed. *C. S. Davis* retired from his position as president of the organization for the past 21 years to accept the newly created office of chairman of the board. *Roy C. Ingersoll,* vice president, was elected president, and will also assume the duties formerly assigned to the office of the executive vice president. *G. A. Shallberg,* previously executive vice president, was named chairman of the Executive Committee. A new vice president was also selected. He is *A. P. Emmert,* president of the corporation's Warner Gear Div., a position which he will continue to hold.

David E. Davidson has been elected vice president for sales of the Link-Belt Co. All other officers who served last year were re-elected. It was also announced at the same time that *Eugene P. Berg,* formerly assistant general manager, succeeds Mr. Davidson as general manager of the Pershing Road plant.

The appointment of Dr. *George Sachs* as vice president of Horizons, Inc. has just been announced. Dr. Sachs is well-known as an expert in mechanical metallurgy.

Ray P. Winberg has been named vice president of Revere Copper & Brass, Inc., in charge of the Rome (N. Y.) Div. He succeeds *Forrest E. Richmond,* who is retiring.

Ing-Rich Metal Products Co. has announced the appointment of the following officers of the company: chairman of the board, *J. F. Ingram;* president, *E. E. Reagle;* vice president, *L. W. Ingram;* secretary and treasurer, *D. L. Brooks;* and assistant secretary and assistant treasurer, *F. B. Reese.*

Douglas M. Considine has been named manager of the market extension division, general sales, of the Brown Instruments Div. of the Minneapolis-Honeywell Regulator Co.

Union Carbide & Carbon Corp. has appointed *H. M. Rich, Jr.* division vice

ACP
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PAINT BONDING

"Granodine" forms a zinc-iron phosphate-coating bond on sheet metal products — automobile bodies and fenders, refrigerator cabinets, etc. — for a durable, lustrous finish.

"Lithoform" makes paint stick to galvanized iron and other zinc and cadmium surfaces.

"Alodine", the new ACP protective coating chemical for aluminum, anchors the paint finish and protects the metal.

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"Permadine", a zinc phosphate coating chemical, forms on steel an oil-adsorptive coating which bonds rust-inhibiting oils such as "Granoleum."

"Thermoil-Granodine", a manganese-iron phosphate coating chemical, forms on steel a dense crystalline coating which, when oiled or painted, inhibits corrosion.

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The oiled ***"Thermoil-Granodine"*** coating on pistons, piston rings, cranks, camshafts and other rubbing parts, allows safe break-in operation, eliminates metal-to-metal contact, maintains lubrication and reduces the danger of scuffing, scoring, galling, welding and tearing.

IMPROVED DRAWING AND EXTRUSION

"Granodraw" forms on pickled surfaces a tightly-bound adherent, zinc-iron phosphate coating which facilitates the cold mechanical deformation of steel, improves drawing, and lengthens die life.

Write or call for more information on these products. Send for new descriptive folder on ACP Metal-Protective and Paint-Bonding Chemicals.

American Chemical Paint Co.
AMBLER ACP PENNA.

MR. PRODUCT DESIGNER

Here's a stimulating story of design ingenuity and packaging success that you may be able to apply to your problems.

Monsanto makes many versatile plastics that might help improve your product or lower your costs. For skilled technical advice and assistance in plastics, check with Monsanto today.

"We reaped a ripe 18% sales-growth... when we buried habit-itis"

says **KEN SHEEHEY**
President,
Santa Maria Berry Farm,
Santa Maria, Cal.

Santa Maria Berry Farm has found new profits in berries with these boxes developed and molded of Lustrex styrene in a variety of shapes, sizes, and colors by Allied Plastics Company, Los Angeles.

"We're selling *more* berries *faster* than ever before. We've registered a sales increase of 18 per cent in the last twelve months. And we're saving money—increasing profits—at the same time," continues Mr. Sheehey. "All because we rejected 'habit-itis'... 'forgot' that berries had always been packaged in other materials, and investigated plastics."

Santa Maria learned that the new berry box made of Monsanto's Lustrex* styrene has many advantages, sales-appealing and otherwise: The unique lattice-designed package allows shoppers to see its contents clear to the bottom. Available in a variety of colors, the gay plastic container trades the berries *up*... and consumers want it for any of a dozen re-uses, such as serving cookies and candy. Berries can be washed right in the box because the plastic package doesn't waterlog. They get better ventilation, too, and there's less spoilage, so the plastic package actually *saves* money in the long run.

Like this leading berry producer, many other clever merchandisers are harvesting greater sales by packaging such products as candy, nuts, vegetables and meat in these attractive baskets. Perhaps, your products, too, could gain new appeal, wider markets in a sales-impelling plastic container.

Whatever your packaging problem, investigate the many different types of materials supplied by the family of Monsanto Plastics. For instance, you can have a molded package of Lustrex styrene, a fabricated container of rigid transparent Vuepak* or flexible Ultron* vinyl film. You'll find a plastic package creates a luxury look at low cost. Send today for information about Monsanto Plastics for packaging. *Reg. U.S. Pat. Off.

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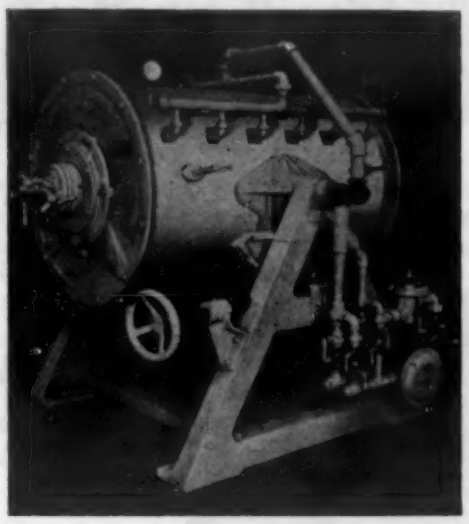
ROTARY GAS CARBURIZERS

A "First" by A.G.F. Co.



Versatility is the outstanding characteristic of AGF Rotary Gas Carburizing Furnaces, which may be used not only for carburizing, but also for clean hardening, normalizing, annealing, and other general or atmospheric work without modification to the furnace of any kind.

Uniform heating of the work is assured by the gentle mixing produced by the rotary action of the retort, which is heated by numerous carefully distributed and balanced gas burners. Carburizing or atmosphere gas is introduced through a simply-designed, trouble-free connection.

Charging and discharging of the work is accomplished by means of a tilting feature, which is power-driven on the larger models. The retort remains within the heat at all times.

The furnace shown above is the latest, improved AGF Rotary Gas Carburizer, batch type, with new maintenance-free roller bearing retort support.

AGF gas carburizing equipment also includes Continuous Rotary Furnaces and Vertical Retort Carburizers. Write for literature.

AMERICAN GAS FURNACE CO.

142 SPRING ST., ELIZABETH, N. J.

president of the Electro Metallurgical Div. Mr. Rich will make his headquarters in Pittsburgh.

A. J. Edgar, general manager of Hunt-Spiller Manufacturing Corp., has been elected a vice president of the company.

The death of *L. D. Holland,* assistant to the president and a member of the board of directors of E. F. Houghton & Co., occurred after a long illness.

The Carpenter Steel Co. has announced the death of *Wynn F. Rossiter,* assistant to the vice president.

News of Companies

The *American Cyanamid Co.,* New York City, announces the formation of the Dyes & Chemicals Export Dept., which will handle all foreign activities in connection with the products of the Company's Calco Chemical Div. (except pharmaceuticals), Industrial Chemicals Div., and Plastics & Resins Div. The combined department will be under the direction of Fraser M. Moffat, Jr. H. E. Lorenz was appointed manager and J. C. Martin assistant manager of the Eastern Hemisphere, while Henry W. Rojas was named manager and W. T. Casey assistant manager of the Western Hemisphere.

The factory and offices of *Kulite Tungsten Co.* have been removed to new and larger quarters at 723-725 Sip St., Union City, N. J.

Completion of a plant reconstruction and expansion program has been announced by the *Metalloy Corp.,* Minneapolis, Minn., division of the Lithium Corp. of America. Increased plant facilities and the latest in extracting and processing equipment were major phases of the overall plan.

A new company has been organized by Dr. Marcus Thau, to be known as *Universal Coatings, Inc.* Located at 10 Avenue C, Newark 5, N. J., the new organization will create engineered finishes to meet specific industrial problems.

The *Formica Co.,* Cincinnati, Ohio, has begun construction of a new plant on Reading Rd., Sycamore, Ohio. This first phase of a $7,000,000 expansion program planned by Formica is expected to be ready for occupancy late in the fall of 1950, and will house finishing, inspection, packing, shipping and raw material warehousing facilities for the Company's decorative laminated plastic products.

The Isotopes Div. of the Atomic Energy Commission has authorized the *St. John X-Ray Laboratory,* Califon, N. J., to

News Digest

handle Cobalt 60 on a rental basis. T and other radioactive materials may a be purchased through the St. John X-R Laboratory.

The *Riverside Metal Co.,* Riversi N. J., has appointed the *William M. C Co.,* Pittsburgh, Pa., as a warehousing d tributor in western Pennsylvania, easte Ohio, and West Virginia.

For excellence of company publicatio promoting interests of the communi *Lebanon Steel Foundry,* Lebanon, Pa., h received the 1949 Award of Merit co ferred by the American Association f State and Local History.

The *United States Testing Co., In* Hoboken, N. J., has been awarded a ma contract to handle inspections of all stru tural steel for bridges on New Jerse new turnpike.

"The Case for Color", a new 25-mi 16-mm. sound movie in color, has ju been released by *E. I. du Pont de Nemo & Co. (Inc.),* Wilmington, Del. The fi explains "Color Conditioning", du Po painting plan involving the functional u of color wherever people work or congr gate. Showings to interested parties m be arranged without cost by writing to t Finishes Div., E. I. du Pont de Nemo & Co. (Inc.), Wilmington 98, Del.

The *American Welding & Manuf turing Co.,* Warren, Ohio, received t second Distinguished Service to Safe Award from the National Safety Counc Only 99 companies in the entire count have ever received this second award.

News of Societies

Horace Gooch, Jr., founder and trea urer of Worcester Moulded Plastics Co was re-elected president of the *Society the Plastics Industry, Inc.* Other officer elected at the same meeting were: chai man of the board—George H. Clark, vic president of the Formica Co.; vice presi dent—Spencer E. Palmer, assistant vic president of Tennessee Eastman Corp and secretary-treasurer—J. E. Gould, vic president of Detroit Macoid Corp.

Max W. Lightner, manager of the Re search & Development Div. of Carnegie Illinois Steel Corp.'s Research & Tech nology Dept., has been elected by th Penn State Chapter of the *American Soci ety for Metals* to receive the annual David Ford-McFarland Award for Achievemen in Metallurgy. The Award was establishe

NEW LOW TESTING RANGES!

WITH OLSEN "L" TYPE UNIVERSAL TESTING MACHINE

"Atcotran" Electronic Null System now available on New Olsen "L" Machines — or can be added to present units.

The Olsen low cost "L" Universal Testing Machine ow becomes more versatile than ever. Available n standard capacities of 60,000 lbs., 90,000 lbs., 20,000 lbs., 300,000 lbs., and 600,000 lbs. with sual selected secondary ranges of 10,000 lbs., 0,000 lbs., 30,000 lbs., 60,000 lbs. and 100,000 lbs. espectively—new "extra low" capacity ranges are ow possible on these machines with the addition f the "Atcotran"* unit. For example, a 60,000 lb. nd 10,000 lb. machine can be readily provided ith an extra low range of 1,000 lbs., reading by 2 b. dial marks. And in addition, load changes may e made without stopping the test.

For accurate tension, compression, and transerse testing the new Olsen "L" Type Universal unsurpassed for versatility and low cost — whether used for production, and quality control esting or instruction.

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*The "Atcotran" was developed in conjunction with the Automatic Temperature Control Company, Philadelphia. An electronic null system consisting of only three moving parts, it receives signals from the developed hydraulic pressure in the precision cylinder of the "L" machine and electronically translates them into the rotary motion of the pointer. This system is extremely accurate and the low ranges which it makes possible are guaranteed accurate within ASTM requirements.

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See our Exhibit at A.S.T.M. Convention, Atlantic City, June 26-30

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☐ Compression ☐ Tensile
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News Digest

last year as an annual recognition of the Penn State metallurgist who, in the opinion of the Award Committee, has brought the greatest credit to himself and his alma mater in the metallurgical profession.

The *Metal Powder Association* has re-elected B. F. du Pont, sales manager of the Plastics Metals Div. of National Radiator Co., as president for the coming year. T. L. Robinson, the Wel-Met Co., was re-elected vice president. And W. P. Schenck, superintendent of the Scrub Oaks Div. of Alan Wood Steel Co., was elected chairman of the board.

The Eastern Div. of the *Steel Foundry Society of America* honored the following at a recent dinner: Marshall Post, of the Birdsboro Steel Foundry & Machine Co.; E. M. Schumo, president of the Pennsylvania Electric Steel Co.; and H. K. Pollard, of Treadwell Engineering Co. The occasion marked their completion of 50 years of service to the steel castings industry. G. Clymer Brooke, vice president of the Birdsboro Steel Foundry & Machine Co., who just completed two years as director of the Society, also received a special tribute.

Edward H. Snyder, president of Combined Metals Reduction Co., was re-elected president of the *American Zinc Institute* for a second term. Three vice presidents now holding office were also re-elected: Clarence Glass, Anaconda Sales Co.; George Mixter, U. S. Smelting, Refining & Mining Co.; and Raymond F. Orr, Athletic Mining & Smelting Co. Re-elected as treasurer was Erle V. Daveler, American Zinc, Lead & Smelting Co. And Ernest V. Gent continues as executive vice president and secretary.

The *Society of Industrial Designers* and *Lehigh University* are jointly sponsoring their second Product Design Seminar, to be held at Lehigh June 26 through July 21, 1950. Various phases of industrial design will be discussed by 40 speakers.

Effective Sept. 1950, *Drexel Institute of Technology* will offer evening courses leading to the bachelor of science degree. Students can qualify for the diploma in architecture, chemical, mechanical, electrical and civil engineering, and industrial administration.

The *National Safety Council* has just released something new in training aids, a safety quiz on film entitled "What's Your Safety IQ?" that shows common, unsafe, off-the-job actions and conditions that can cause accidents in the home, in traffic and in recreation. The film is offered both as a 35-mm. sound slidefilm and in a new, inexpensive type of 16-mm. picture, each with the same script and illustrations. Prices for outright purchase, preview or rental may be obtained on request to the National Safety Council, 20 N. Wacker Dr., Chicago 6, Ill.

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125	275	450	1000	1550
138	288	500	1050	1600
150	300	550	1100	1650
163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
200	350	750	1300	1850
213	363	800	1350	1900
225	375	850	1400	1950
238	388	900	1450	2000
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FREE —Tempil° "Basic Guide to Ferrous Metallurgy" — 16¼" by 21" plastic-laminated wall chart in color. Send for sample pellets, stating temperature of interest to you.

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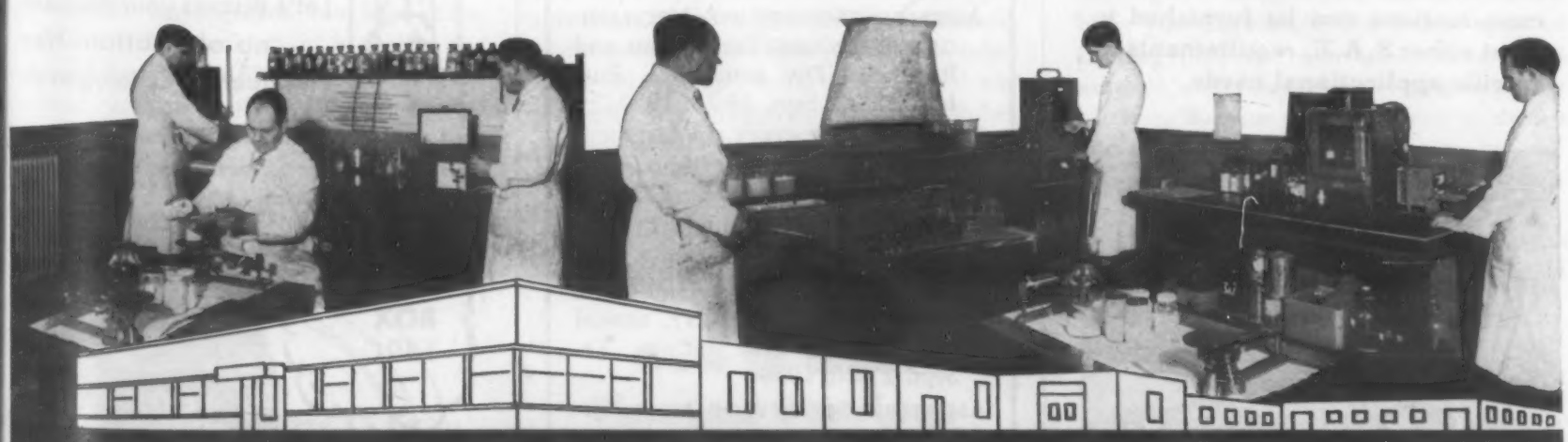

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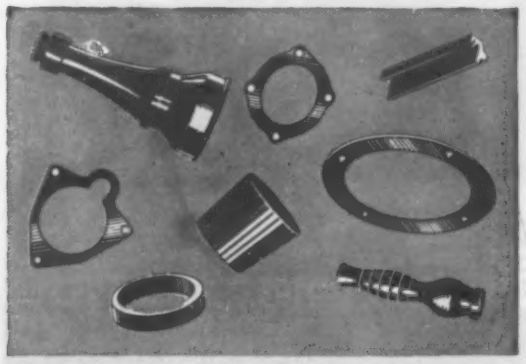

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AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Applied Mechanics Div. conference. Lafayette, Ind. June 22-24, 1950.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting. Atlantic City, N. J. June 26-30, 1950.

AMERICAN SOCIETY OF CIVIL ENGINEERS, summer convention. Toronto, Canada. July 12-14, 1950.

INSTITUTE OF THE AERONAUTICAL SCIENCES, annual summer meeting. Los Angeles, Calif. July 12-14, 1950.

UNITED STATES INTERNATIONAL TRADE FAIR. Chicago, Ill. Aug. 7-19, 1950.

SOCIETY OF AUTOMOTIVE ENGINEERS, West Coast meeting. Los Angeles, Calif. Aug. 14-16, 1950.

NATIONAL ASSOCIATION OF POWER ENGINEERS, national power show. St. Louis, Mo. Aug. 14-18, 1950.

AMERICAN CHEMICAL SOCIETY, national meeting. Chicago, Ill. Sept. 3-8, 1950.

NATIONAL CHEMICAL EXPOSITION. Chicago, Ill. Sept. 5-9, 1950.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic and aircraft engineering display. Los Angeles, Calif. Sept. 11, 1950.

SOCIETY OF AUTOMOTIVE ENGINEERS, tractor meeting. Milwaukee, Wis. Sept. 11, 1950.

PORCELAIN ENAMEL INSTITUTE, annual forum. Urbana, Ill. Sept. 13-15, 1950.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Instruments and Regulators Div. conference. Buffalo, N. Y. Sept. 18-22, 1950.

INSTRUMENT SOCIETY OF AMERICA, national instrument exhibit. Buffalo, N. Y. Sept. 18-22, 1950.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Worcester, Mass. Sept. 19-21, 1950.

STEEL FOUNDERS' SOCIETY, annual fall meeting. Hot Springs, Va. Sept. 25-26, 1950.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, petroleum mechanical engineering conference. New Orleans, La. Sept. 25-27, 1950.

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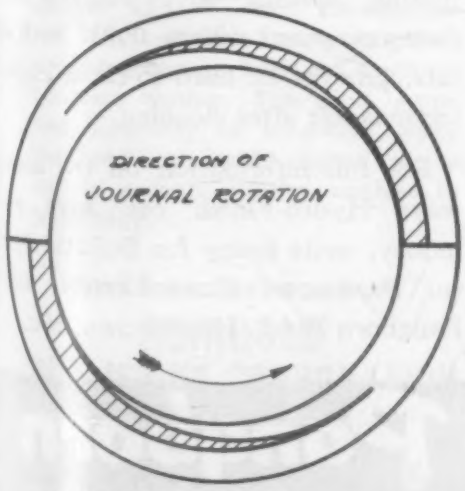
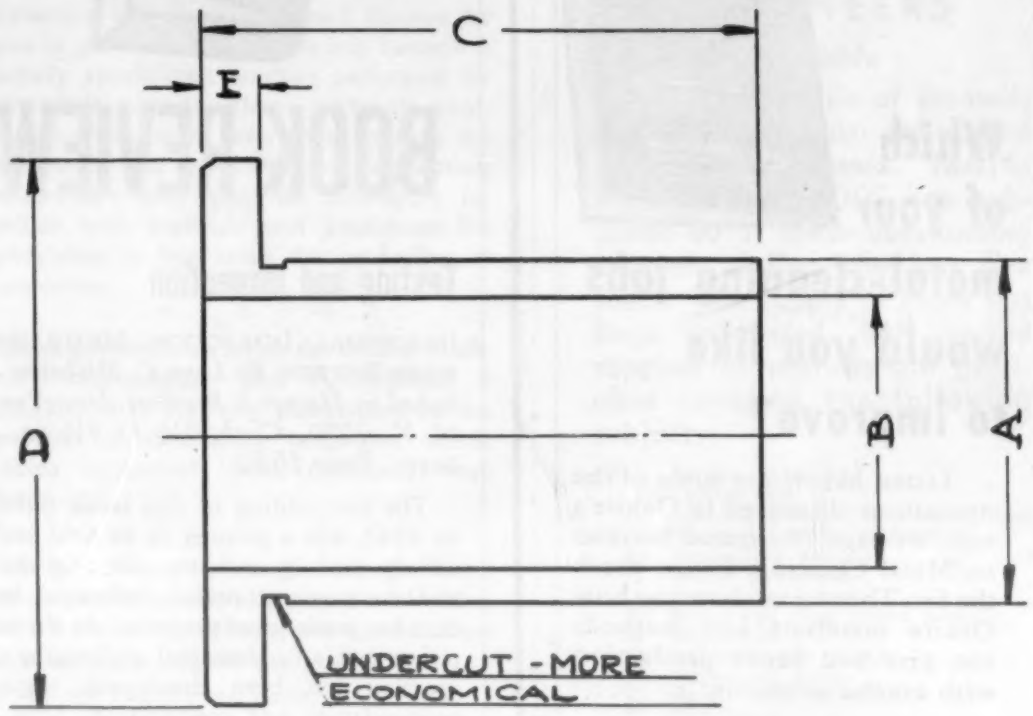
In cast bronze bearings the flange can be located anywhere on the outside diameter and can be made any thickness as required. In sheet metal bearings the location of the flange is limited to the ends and cannot be any thicker than the metal used in the body of the bearing.

In applications where the principal use of a flange is to meet a thrust condition it is well to include oil grooves on the face of the flange. In cast bronze the most popular type is the wedge shape as illustrated herewith. This permits the introduction of oil in order to produce the hydraulic pressure required to separate the flat surfaces. Sheet metal bearings usually employ a design known as "tear drop."

In applications where the operating speed is comparatively slow, it is often wise to use graphite impregnated bearings. The graphite can be included on both the inside diameter and the flange of the bearing. In some cases it is often difficult or impossible to locate the oil intake in the proper place to insure good lubrication while at the same time make it convenient and accessible. The use of flange in applications of this nature provides a reservoir for the lubricant. The oil intake can be placed in the most convenient place on the housing while the corresponding hole in the bearing can be placed where operating conditions demand.



Recommended type of groove on face of flange.



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A. Outside diameter of bearing.
B. Inside diameter of bearing.
C. Length—over-all—of bearing.
D. Outside diameter of flange.
E. Thickness of Flange.

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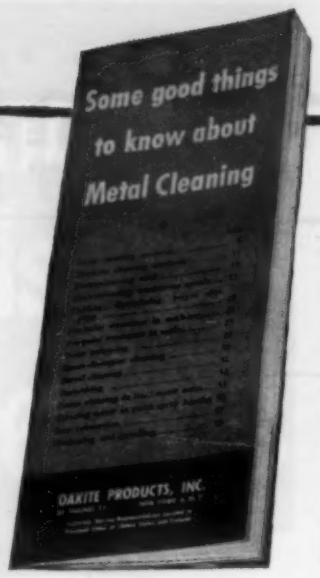

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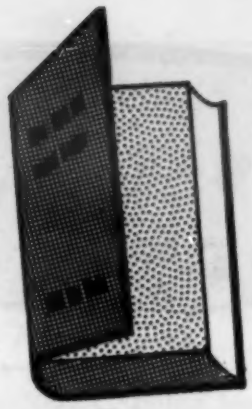

BOOK REVIEWS

Testing and Inspection

INDUSTRIAL INSPECTION METHODS. REVISED EDITION. *By Leno C. Michelon. Published by Harper & Brothers, New York 16, N. Y., 1950. Cloth, 6½ by 9½ in., 566 pages. Price $6.00.*

The first edition of this book, published in 1942, was a pioneer in its field and was widely used in industry. During the war and the post-war period, industrial inspection has made great progress. As the author points out, a fundamental philosophy of inspection has been developed; inspection nomenclature and specifications have been standardized; a wide variety of new inspection tools and devices have been developed to meet the quality standards of thousands of intricate parts; and statistical methods have been enlisted.

This new edition is a basic but comprehensive presentation of the principles and practices of industrial inspection work as it exists today. The major divisions of the work are concerned with basic concepts, dimensional control, testing for physical and mechanical properties, surface inspection, and inspection organization and personnel.

A list of subjects covered by each chapter gives a good indication of the scope of this book. These subjects include: introduction to dimensional control; nonprecision measurement; precision measurement by micrometers and verniers; plug, ring and snap gages; gaging policy; precision gage blocks; comparison measurement by dial indicators and indicating gages; precision angle measurement; screw threads and thread gages; comparison measurement by comparators and automatic gaging; optical instruments in industrial inspection; surface plates and toolroom specialties; supermicrometer and measuring machine; typical inspection problems; statistical methods of quality control; mechanical properties and destructive testing; hardness testing; magnetic particle inspection; nonmagnetic methods of nondestructive testing; industrial radiography; surface inspection; and organizing for the effective control of quality.

Other New Books

MANUAL OF OPEN DIE FORGINGS. *Published by the Open Die Forging Industry, New York 17, N. Y., 1949. Cloth, 6¼ by 9¼ in., 181 pages. Price $3.00.* A technical manual, prepared by the members of the Open Die Forging Industry, that covers the methods, practices, specifications and inspection used in the manufacture of open die ferrous forgings.

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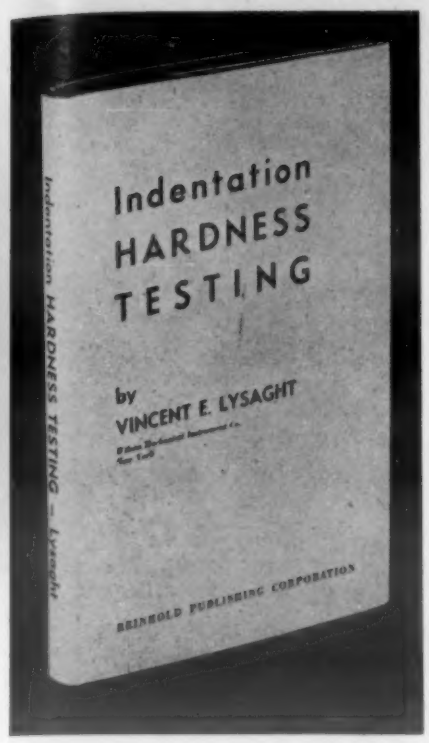

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Whether you are a metallurgist, a testing engineer, a machine operator or a student, you will find much of value in this complete story of hardness testing. The more advanced student and research investigator will find sufficient theory to afford a comprehensive basis for practical hardness testing. The plan, scope and simplicity of language make the book admirably suited for a text in schools offering courses in metallurgy.

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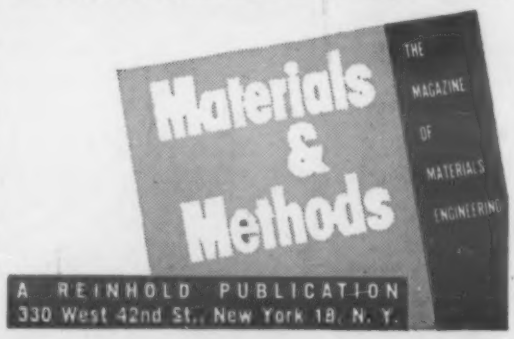

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EDITORIAL

Unite for Research

On this page a few months ago we suggested that it might be smart for materials producers to learn more about their materials through fundamental research. Many people feel that if answers to basic materials problems were found, we would all benefit. Benefits would be found in better materials of all types as well as in the development of materials better to meet specific needs.

While it is easy enough to predict what individual materials will do under certain conditions, the question of "why" usually remains unanswered. Progress to date has been largely a development of theories and great dependence on trial and error to produce satisfactory materials. Research and experimentation has been largely up to individual companies.

The crux of the problem apparently lies in the fact that research is largely an individual effort. Few, if any, companies can afford the luxury of a sustained research program which does not promise eventual profit. Research programs are usually devoted to finding the answers to urgent or anticipated commercial problems.

Government research projects involving the atom and meson give some clues as to the make-up of materials and might lead to the information we need. However, it would not seem wise to leave all research work to the government or to private institutions working under Federal grants.

What then is the hope of having such research?

It would seem a smart move for materials producers to unite in sponsoring basic research which could help each and every one of them. Perhaps it might be too much to expect all materials groups to go together in such a project, but the iron and steel producers might take the lead in finding out why materials behave as they do.

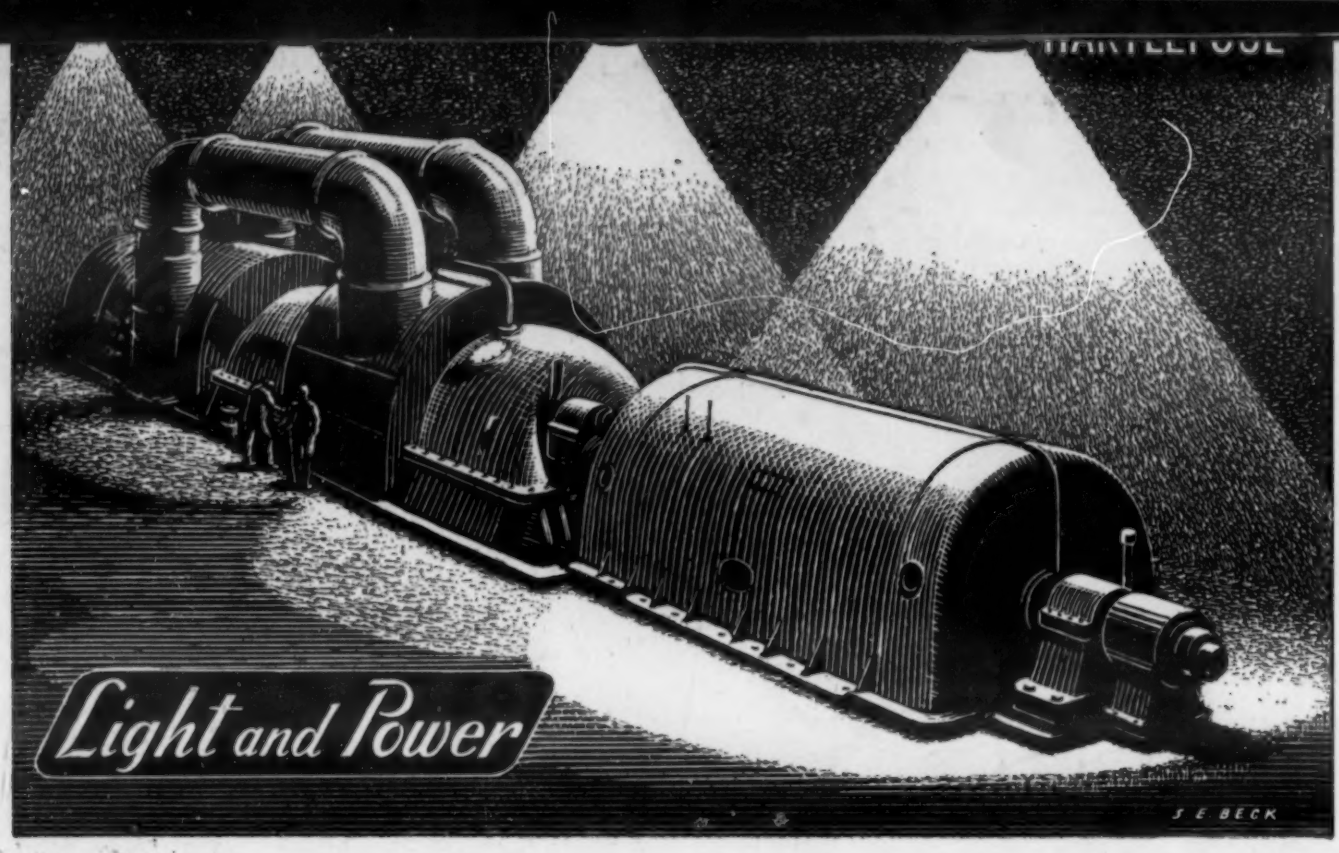
Possibly such an established group as the American Iron & Steel Institute could promote an orderly, long range research program. It might even be necessary to construct its own laboratory facilities.

As long as we are dreaming along these lines we might as well make more complete plans. Facilities could be built at some college or university for the research program. Then, after several years of intensive research, the laboratories could be turned over to the school. Then, while operated by the school for general research work, it could be held in reserve for continued materials researching when the need presented itself.

What would the researchers look for? That will be no problem, for nearly any materials engineering man has several fundamental questions he would like answered. Perhaps we can even find a satisfactory explanation of fatigue in metals.

At any rate, the suggestion that research be undertaken should receive more than passing consideration.

T. C. Du Mond
Editor



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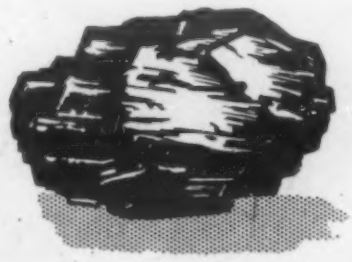

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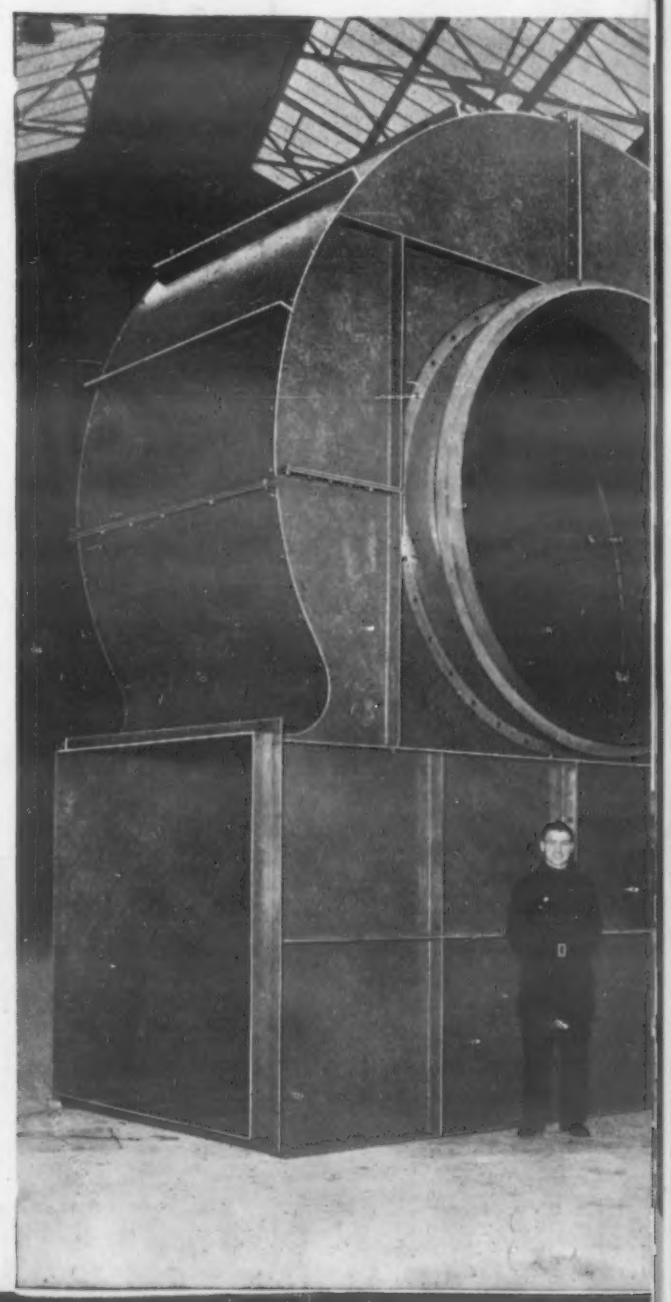

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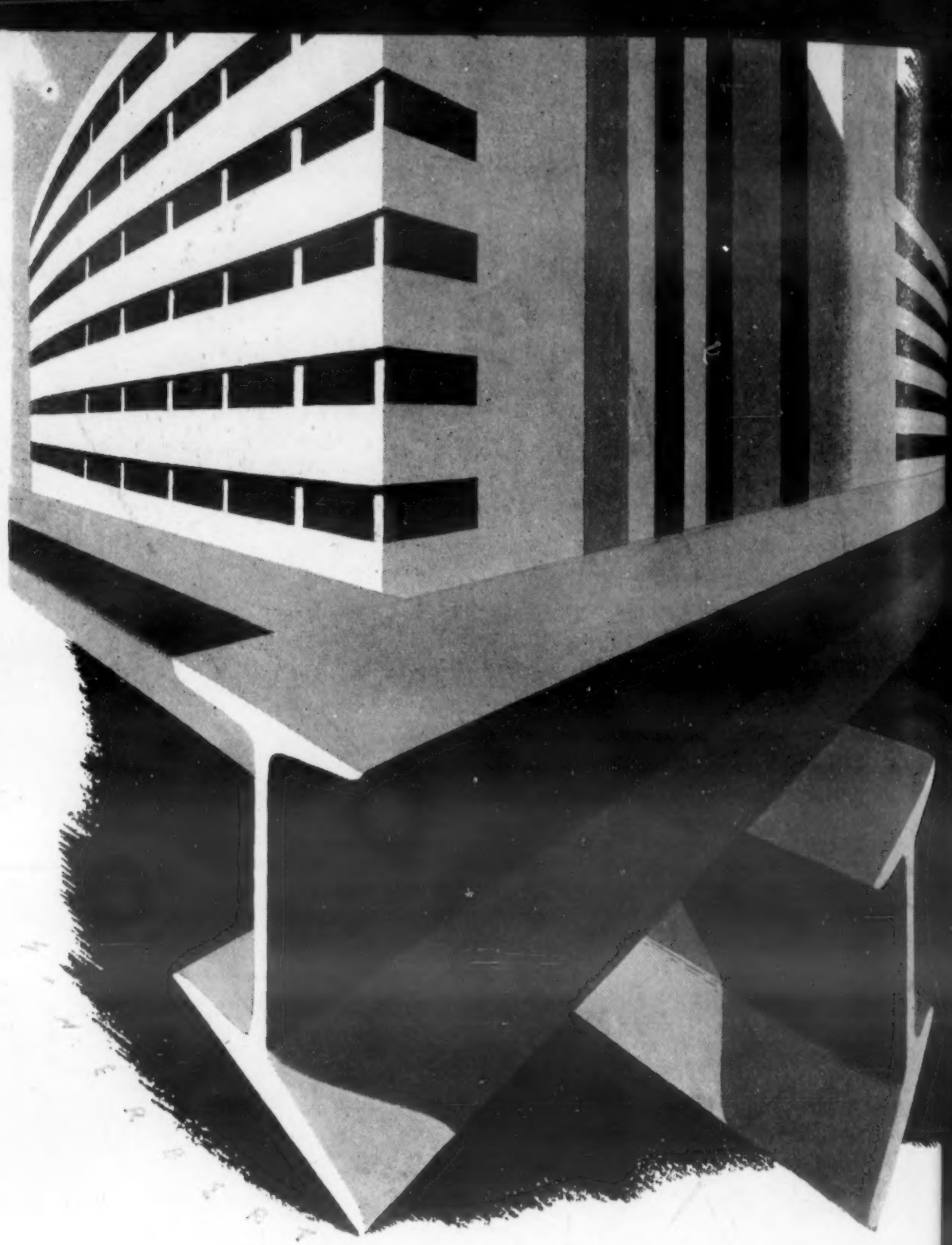

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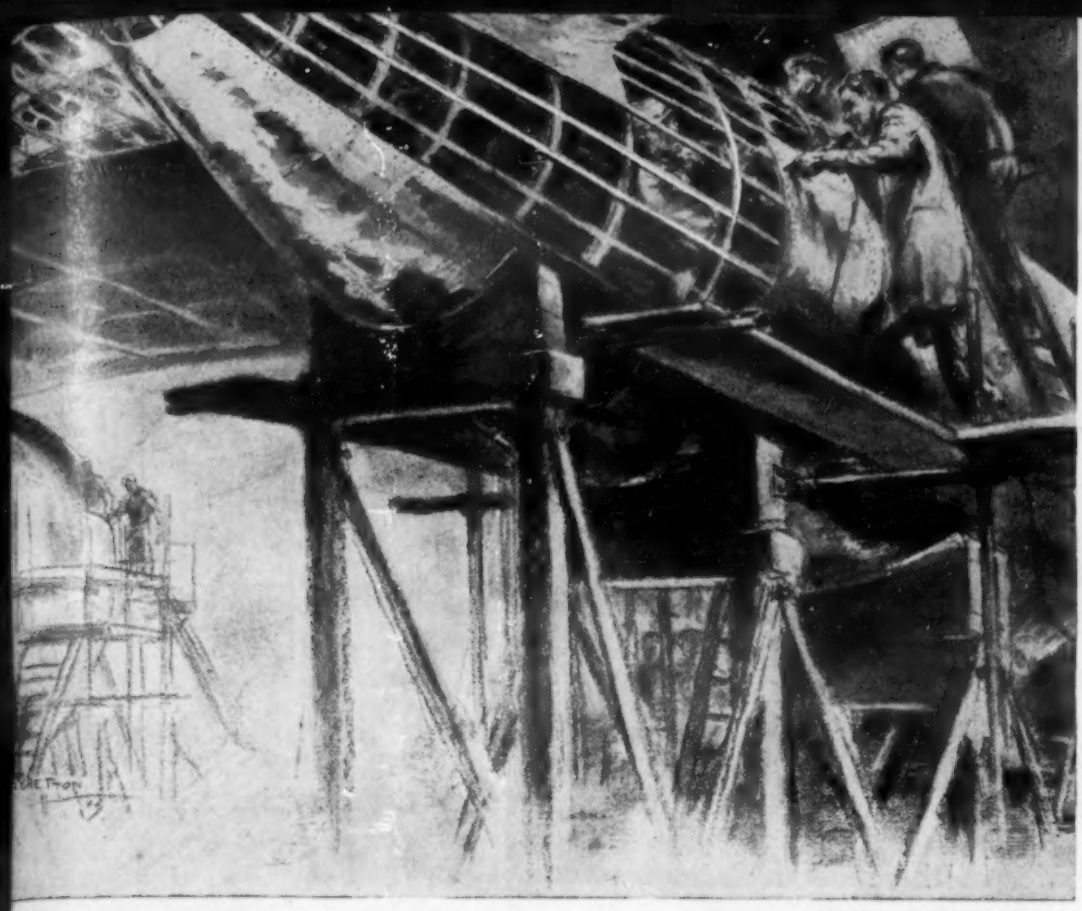

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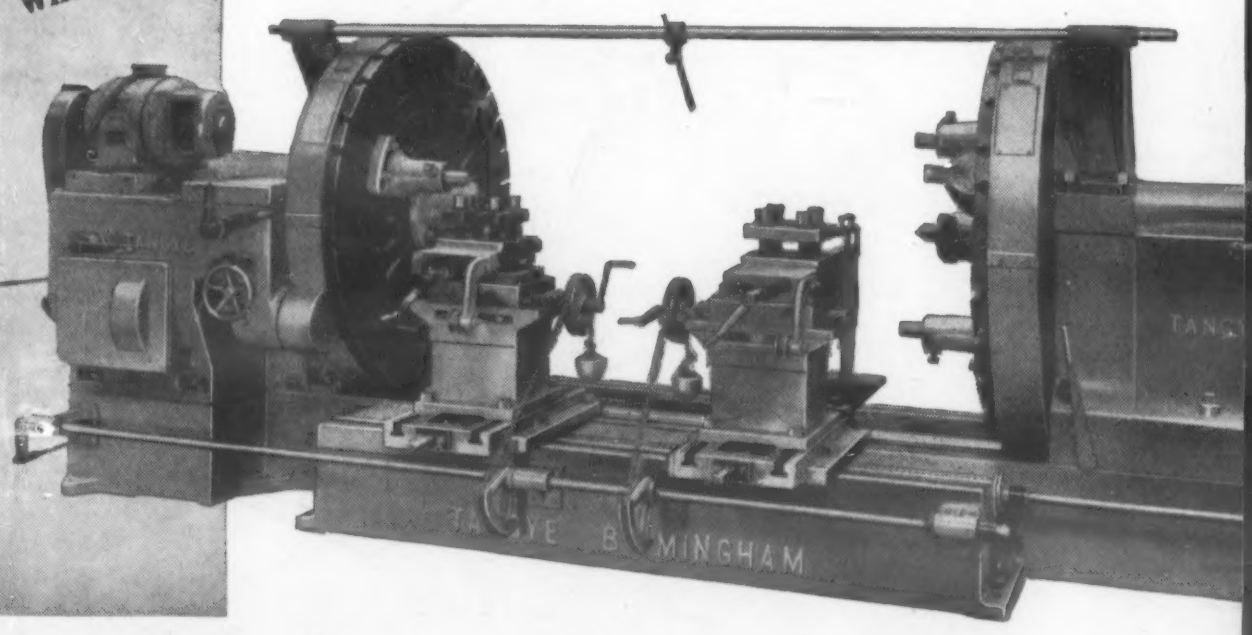

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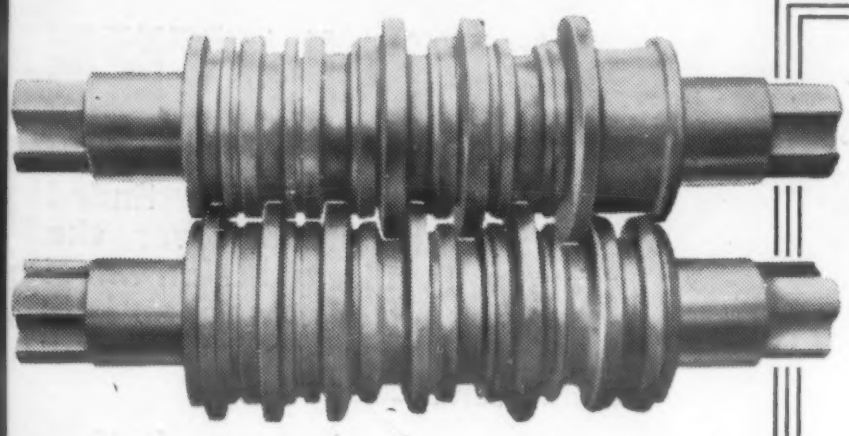

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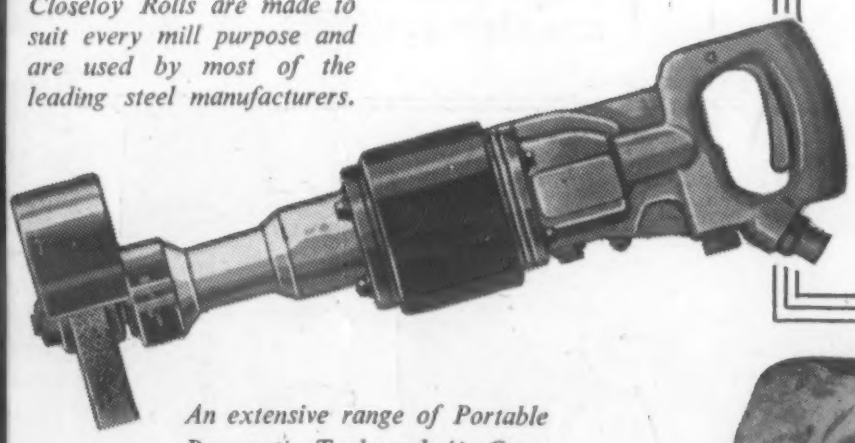

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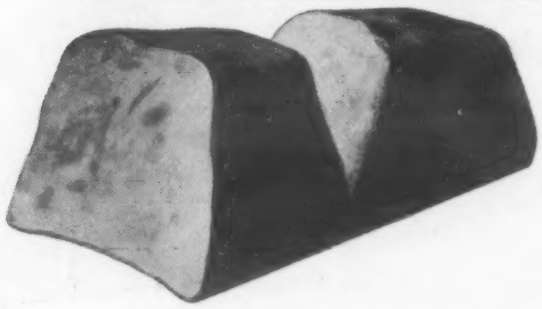

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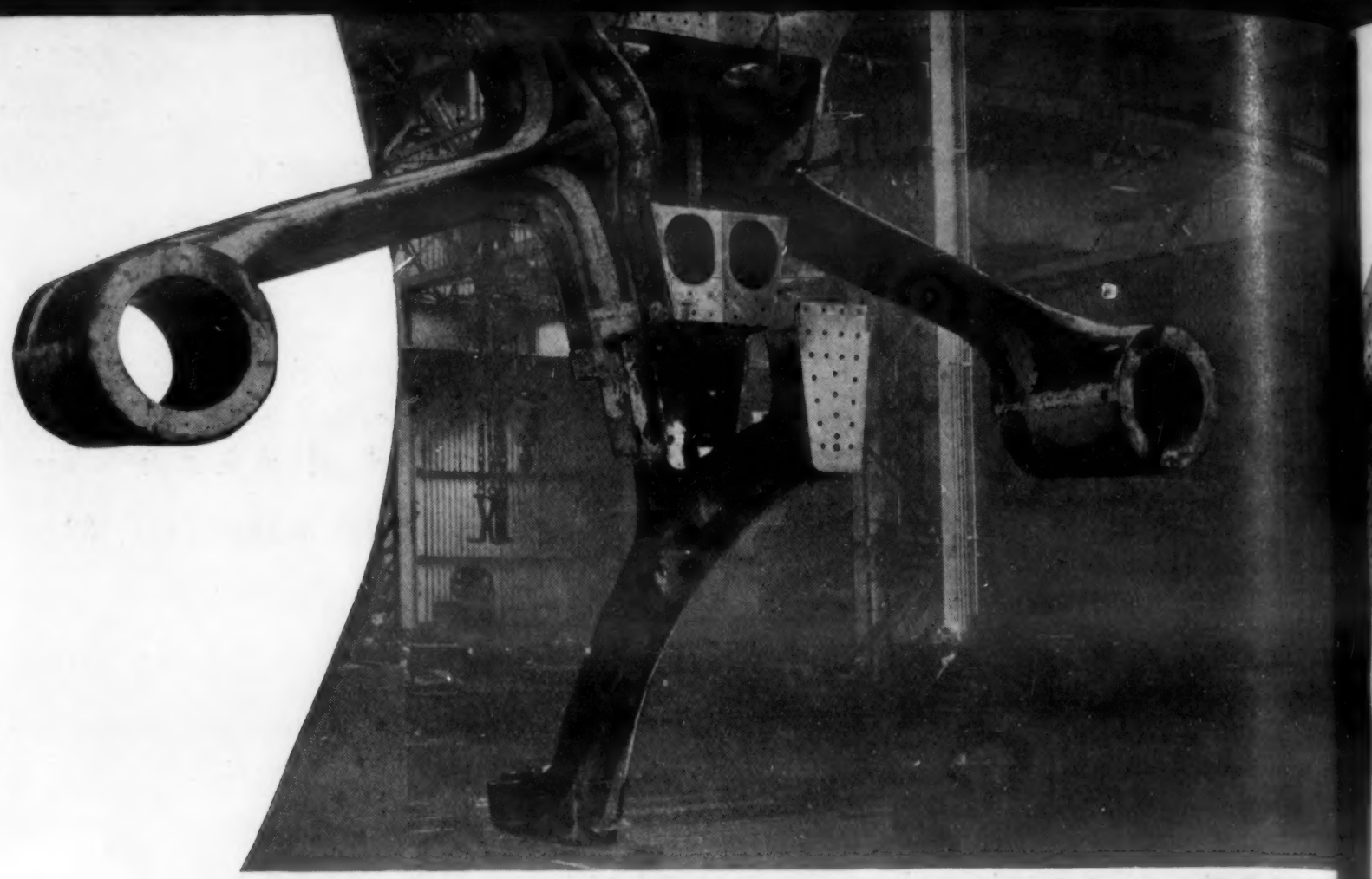

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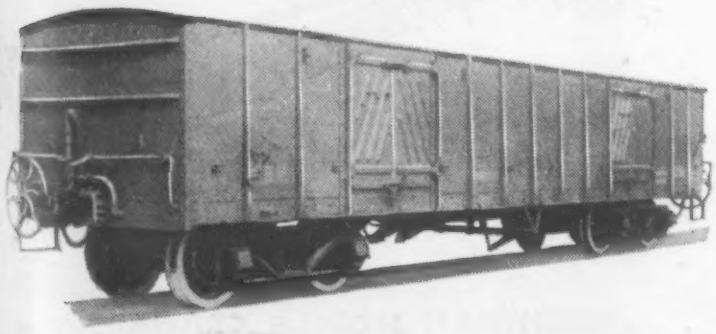

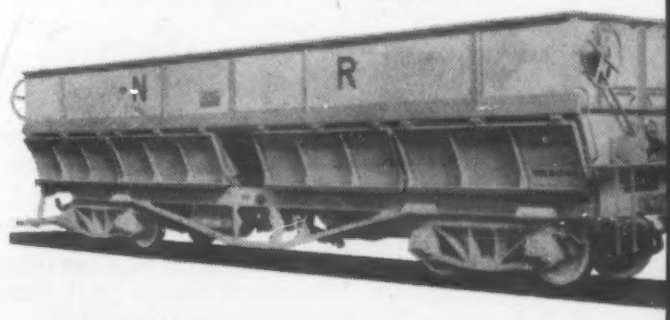

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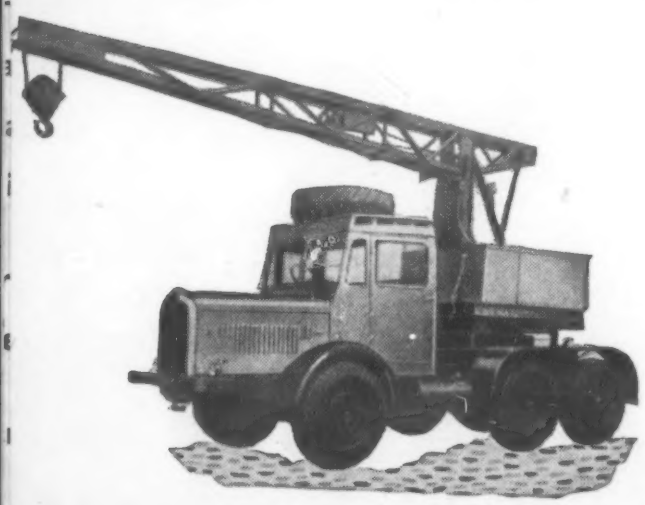

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